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Smithsonian August/September 1993

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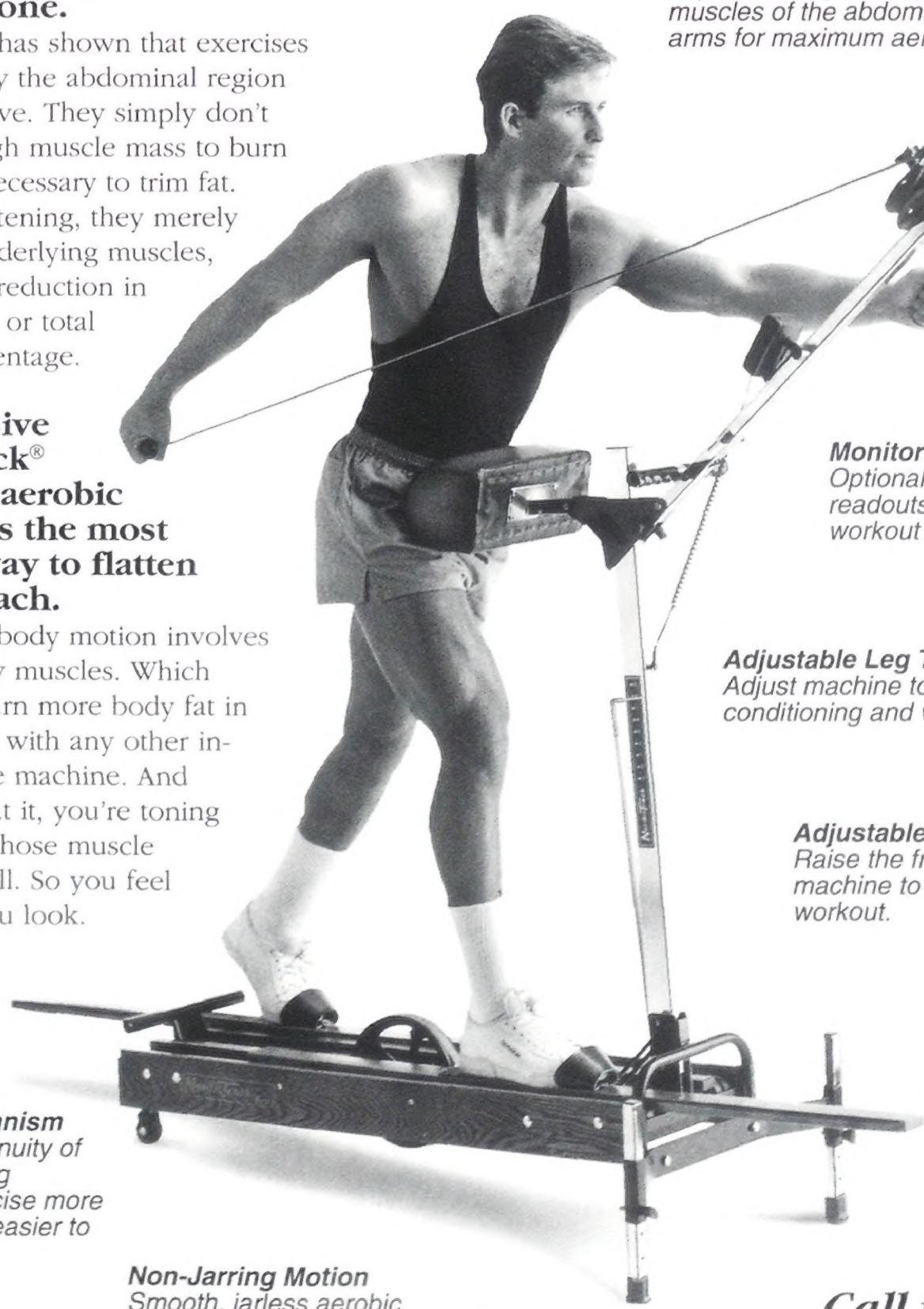
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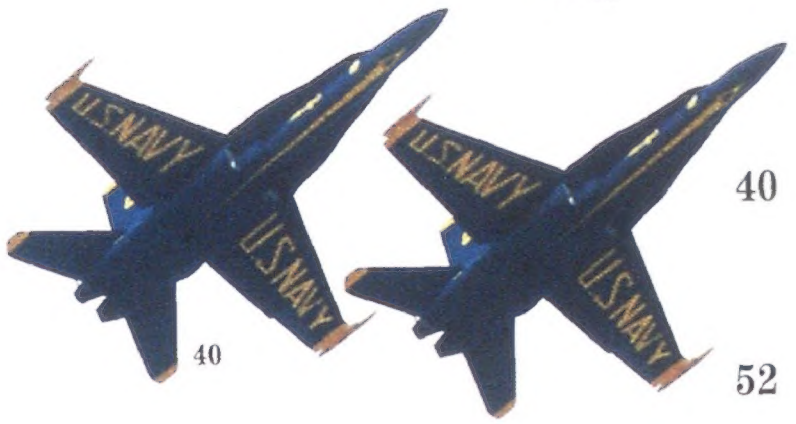
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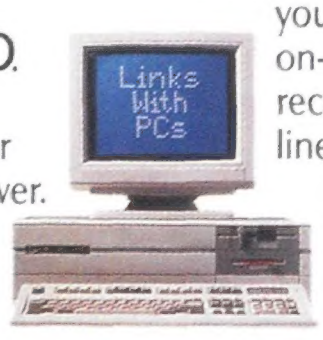
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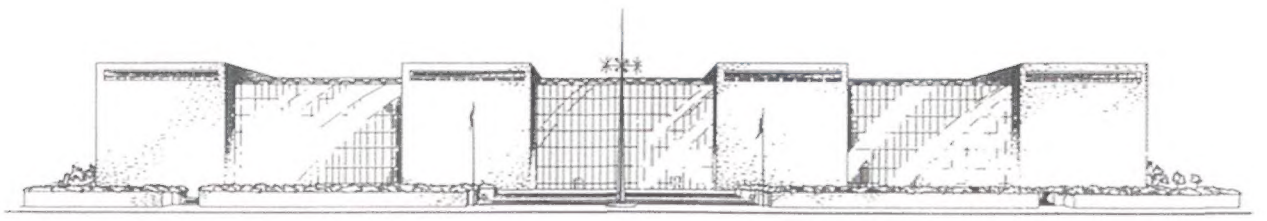
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Why Star Trek?

In late February the National Air and Space Museum opened its most recent gallery; it features the late-1960s television series Star Trek.

Star Trek? Why Star Trek? Many of the Museum's strongest supporters have written me over the past few months, disturbed by this intrusion of fiction into a museum seriously dedicated to aviation and spaceflight.

The Star Trek exhibition has stunned all of us at the Museum with its popularity. Attendance has exceeded that of any previous exhibit. For the first time, we've issued passes to regulate the flow of visitors, preventing overcrowding. But popularity in itself is no justification. For the Museum to mount an exhibition it must have substance.

When Mary Henderson, the Museum's curator of art, first conceived the exhibition, she was fascinated by the way this space fiction series reflected the popular thought of its times. Woven into this Odyssey set centuries in the future were themes aired on the evening news only hours before. The cold war, the Vietnam conflict, racial uprisings, the women's movement—all were repeatedly reflected in Star Trek episodes.

Why should space be the setting for vivid debates on the agonizing political dilemmas of the 1960s? Why were millions of people watching the show week after week? Why has the original TV series become such a cultural phenomenon? Why is the Star Trek fan movement still so strong even today? The answers aren't at all clear, and that's why we are asking visitors to the Museum to ponder these issues.

Beyond considering this cultural phenomenon, however, the Museum had a second purpose in mounting the Star Trek show. Space fiction, perhaps more than any other factor, has inspired every major pioneer in the development of modern rocketry and space exploration.

Konstantin Tsiolkovsky (1857–1935), the great Russian pioneer and visionary whose works laid the theoretical foundations for rocket science and spaceflight, was in his early 20s when he began thinking about space travel. "I do not remember exactly what prompted me to make calculations...," he wrote. "Probably the first seeds of the idea were sown by that great fantastic author Jules Verne—he directed my thoughts along certain channels, then came a desire, and after that, the work of the mind."

At the age of 16, Robert Goddard (1882–1945) read H.G. Wells' *War of the Worlds*. "Wells' wonderfully true psychology made the thing very vivid," remembered Goddard, "and possible ways and means of accomplishing the physical marvels set forth kept me busy thinking." Goddard went on to build the first successful liquid-fueled rocket, the culmination of a lifetime's arduous work.

Hermann Oberth (1894–1989), born in Transylvania, became fascinated by Jules Verne's *De la Terre à la Lune* in 1906. He soon realized that rocket propulsion, rather than Verne's cannon projectile, would be essential to minimize stress on the human body during launch into space. Oberth's book *Die Rakete zu den Planetenräumen* became the bible of German rocket enthusiasts in the 1920s, and attracted the 15-year-old Wernher von Braun to join Oberth's group of experimenters and rocket builders.

The young von Braun had also been smitten by the German science fiction writer Kurd Lasswitz's *Auf zwei Planeten*. "I shall never forget how I devoured this novel with curiosity and excitement," he said. This from a giant who had the foresight, understanding, and genius to convince us that a moon landing in the late 1960s was a realizable goal.

So why not dedicate a gallery to Star Trek for a few months? Isn't the nation searching for new ways to inspire our youth to do things that John F. Kennedy once described as worth doing "not because they are easy, but because they are hard"?

That's also the aim of this show!

—Martin Harwit is the director of the National Air and Space Museum.

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Letters

More Losers

The inclusion of the Bell Airacuda in "Lovely Losers" (June/July 1992) was well deserved. I was a mechanic at Chanute Field in Illinois in 1940 and we received most of the surviving Airacudas, which had been taken out of service and used to train airplane mechanics. It had a beautiful shape, but it was nonetheless troublesome. When bailing out, you couldn't exit through the front escape hatch. One pilot who tried got out on the wing and slid to the rear, but there was not enough space between the pusher props and the fuselage and as he slid back over the wing, he was chopped up by the prop. His crew chief parachuted safely by exiting through a door behind the engines.

Another feature that made the Airacuda unpopular with flight crews was the location of the cannons in the front section of the engine pod. The gunners would not ride in there because in an emergency there was no way out except through a hatch that might or might not give them a chance to clear the arc of the props behind them. Air crews breathed a sigh of relief when the Army Air Corps grounded all Airacudas.

Edwin F. Wach
Sierra Vista, Arizona

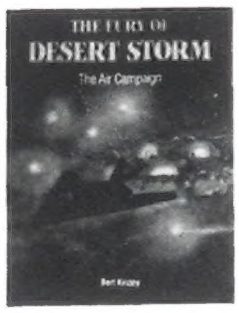
Well, I guess I have strange taste in airplanes. Two of my all-time favorites made your list. While I would have to agree that the Comet deserves inclusion, I think you are being a bit unfair by placing the Arado AR234 in such dubious company. The Arado's ability to outrun any Allied aircraft gave the Germans a reconnaissance capability that they had not known for some time. Given Germany's overall situation from mid-1944 on, I would say the Arado was quite a success.

David Barnes
Houston, Texas

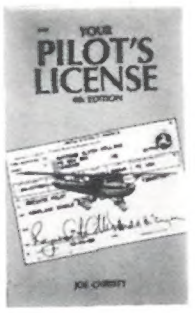
Readers who enjoyed "Lovely Losers" would appreciate Bill Yenne's wonderfully entertaining book *The World's Worst Aircraft* (Dorset Press, 1990). Proving that



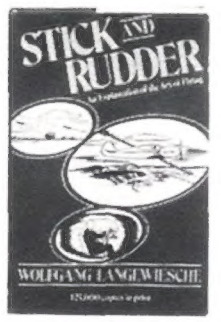
"Yes, I was going very fast, but relative to what?"



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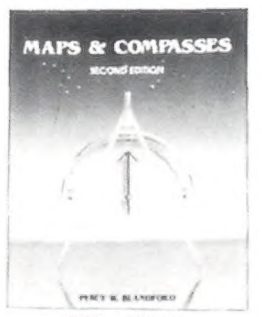
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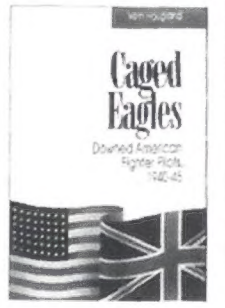
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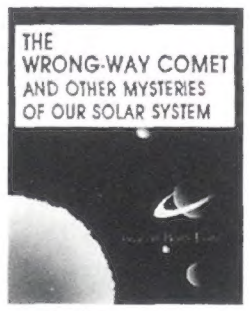
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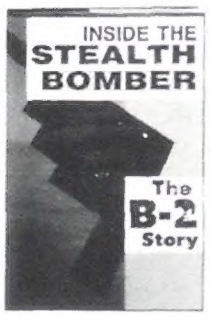
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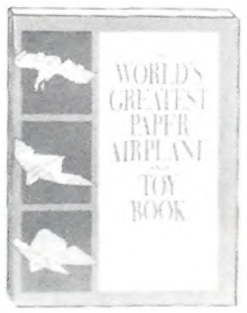
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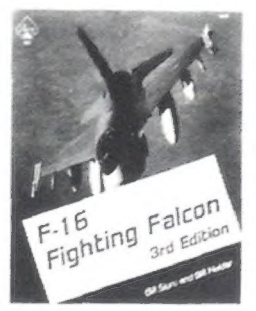
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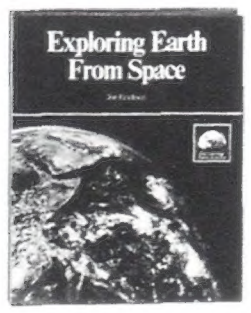
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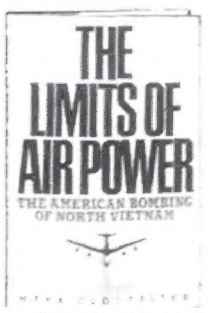
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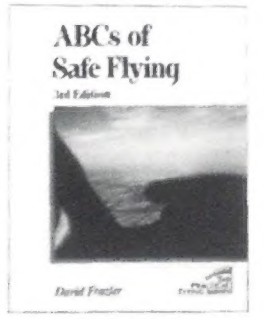
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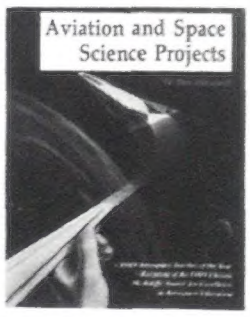
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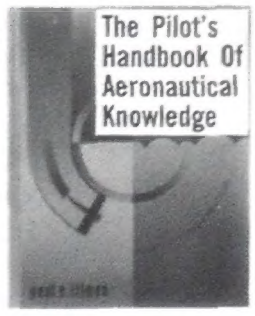
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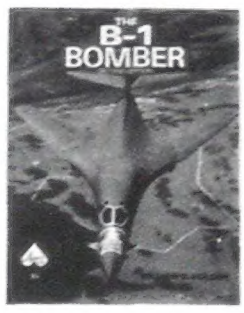
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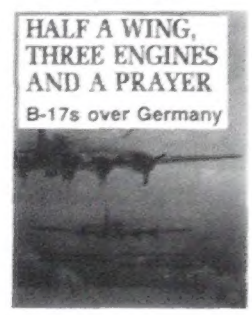
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"No dessert, Mr. Dalrimple, till you finish your vegetables."

great minds do indeed think alike, Yenne includes many of the same aircraft that you did, such as the Brabazon, Seadart, Comet, F-20 Tigershark, and Hughes XF-11. One aircraft that failed to make your list is the stiletto-shaped Douglas X-3, surely one of the fastest-looking aircraft ever built. Unfortunately, it was too underpowered to achieve its goal of Mach 3 flight.

Andy Baird
Hightstown, New Jersey

You left out the Republic "Rainbow" XF-12. If ever there was a beautiful airplane left waiting, this was it.

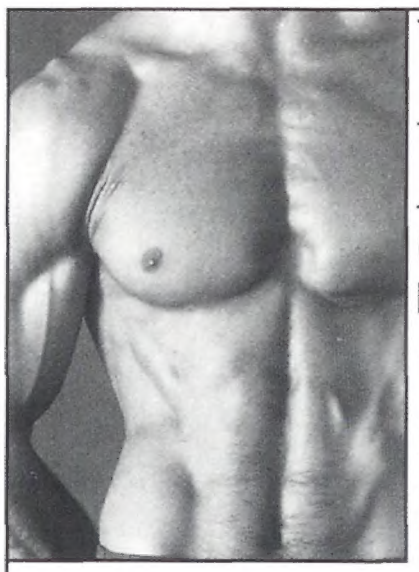
Robert Wynne
Mercer Island, Washington

You forgot the Convair 880 and 990 jetliners, which lost out to the DC-8 and Boeing 707 during the 1960s.

Philip Cavallo
Chicago, Illinois

The Seadart's Demise

It was a pleasant surprise to find the Consolidated Vultee XB-46 and the Convair XF2Y Seadart featured in "Lovely Losers." I participated in the design and development of both aircraft and remember them fondly; they were both excellent and advanced designs. However, to say that the Seadart exploded in flight is not technically accurate. In a flyby before Navy officials, the pilot inadvertently exceeded the airplane's tested speed envelope for his altitude and encountered a violent vertical dynamic oscillation. This has been referred to as a JC maneuver, in which the pilot's attempt to control the aircraft's oscillations results in an out-of-phase situation that rapidly produces extremely high structural load on the airplane. In the Seadart's case, this



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occurred so rapidly and violently that the third or fourth oscillation tossed both engines out of the airplane. However, no fire or true explosion occurred before the airplane dove into the bay. That the accident occurred in front of the aircraft's customer representatives may have been a factor in the Seadart's cancellation. However, many of us in the program felt that the real reason for the cancellation was the opposition of aircraft carrier admirals to a water-based fighter that didn't need large, multibillion-dollar ships.

J.B. Hurt
La Mesa, California

As a young aerodynamicist, I was assigned to the Seadart accident investigation under George Shue. We had precious little to work with except an 8mm film made by the Seadart's crew chief. The first sign of trouble was a pushover of less than 1 G followed by a pullup of about 3 Gs, then a pushover of over –6 Gs. This is when the wings departed the fuselage, which then hit the water. The accident had all the earmarks of classic pilot-induced oscillation, but I felt then as I do now that the fault could not have lain entirely with the pilot, Chuck Richbourg. I knew him to be a careful and capable individual. Poor Chuck was alive when they pulled him from the water but died before he got to the hospital.

A. Bruce Bower
Frazier Park, California

Drag Pilot

I enjoyed reading the story about the Reno air races ("The Last Piston Show," April/May 1992) and would like to add a story of my own. In late 1939, the members of the Reno central labor committee invited me to join them in planning a gala Labor Day celebration to be held the following year. My suggestion was to hold an airshow at Hubbard Field, the United Airlines operational base in Reno. The show opened on September 1 with the playing of the national anthem as a parachutist dropped out of the sky carrying the American flag. We had a closed-course pylon race and a bomb-dropping event using sacks of flour.

There was also a comedy act that relied on a bit of deception. A free airplane ride would be given to the oldest woman attending the show. A "Mrs. F.O. Smith" came forward and said that she was 90 years old. She used a cane and wore an old-fashioned dress, high button shoes, and a straw hat decorated with flowers.



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It could have been a bullet through a gas line, a broken prop, a severed control cable, or just a dud engine that gave up the ghost over the lines; it didn't matter which. This Sopwith Camel pilot from the American 148th Squadron likely had his hands full just getting back to the Allied side of the lines. Luckily he has fallen into the friendly hands of British and Canadian troops, who welcome this unexpected guest with a healthy tot of medicinal brandy.



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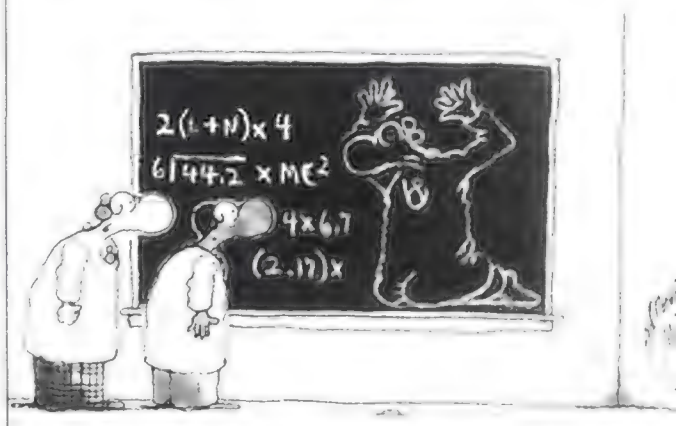
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Somewhat shaky, she required assistance getting into the back seat of an old Cub. When she was strapped into the back seat and ready to go, the pilot, who stood near the Cub, pulled the prop through. The ignition switch was on and the throttle had been opened wide. When the engine caught, the airplane jumped forward, leaving the pilot behind. As a startled Mrs. Smith tried to get out, the Cub sped toward the runway with the Reno fire department in hot pursuit. After bouncing up and down on the runway several times, the Cub finally took off and disappeared behind a row of low trees. The crowd was horrified. A woman standing near me grabbed her child and rushed away, saying, "I am not going to stand around and see that poor old lady get killed." Many others jumped into their cars and drove to where they thought the Cub had crashed. Meanwhile, Francis O. Smith, experienced pilot, flew low behind the trees and landed in back of the spectators, then taxied up to the crowd to the sound of great applause. To my knowledge, this was the first Reno air race. I was very proud to be part of it.

Larry Carmody
Camarillo, California

The Day the World Changed

"Ground Zero" (Collections, June/July 1992) set me back in time to 5:30 a.m. on July 16, 1945, over Albuquerque, New Mexico. I was the pilot of a naval air transportation R4D (DC-3) heading east at 12,000 feet with a crew of three and 15 passengers. The air was smooth and clear, the sun not yet up. Suddenly the sun rose almost due south of my position, or so it seemed. The object that I saw pulsed and faded in a most un-sunlike manner. All aboard my airplane were transfixed by the brilliant sight. The best guess was that an ammo dump had exploded. Every radio was tuned to a different station in the hope that some



"It looks like Bosworth found that portal to the fourth dimension."

explanation of what we had seen would be forthcoming. We learned nothing.

It was not until the war with Japan ended and the first atom bomb test was announced that I learned what had happened that day. We had witnessed the dawn of the atomic age from a distance of nearly 160 miles, and the world would never again be the same.

Samuel G. Burtis
Camden, Maine

American Made

So the myth about Japan continues. "You Are Here" (June/July 1992) says that navigation systems are being installed in Japanese cars. This may be, but you are certainly overlooking the fact that this system is available in General Motors automobiles. In Florida, you can rent GM cars equipped with a navigation system called Travek.

G.P. Goecke
Fargo, North Dakota

What I Learned at Space Camp

I really enjoyed your article on Space Camp ("I Was a Teenage Astronaut," June/July 1992). I too was a teenage astronaut when I attended Space Camp in March. Those eight days were some of the most fun-filled and exciting of my life. Aside from all I learned in lectures and missions, I made some of the best and most diverse friends that I have so far. I am in the 10th grade. Ever since fourth grade I have wanted to be an astronaut. Not only did Space Camp reassure me that I really did want to become an astronaut, but it also helped me decide which type I would like to be: commander.

Emily Schwartz
Westtown, Pennsylvania

Correction

In "Germany's Atlantic Air Bridge" (June/July 1992), the caption on page 74 misidentified a BV 222 as a BV 238.

We welcome comments from readers. Letters must be signed and include a daytime telephone number. Letters may be edited. Write to Air & Space/Smithsonian, *370 L'Enfant Promenade SW, 10th Floor, Washington, DC 20024.* Air & Space *is not responsible for the return of unsolicited photographs or other materials.*

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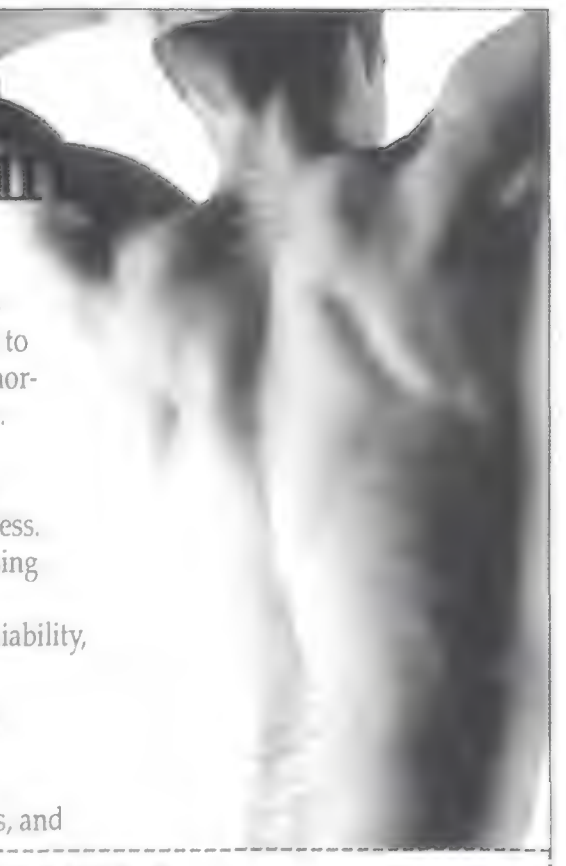
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The Mad Monk Chapter



JORDAN COONRAD

It began last November over the free tacos served at the officers' club at Edwards Air Force Base in California. Captains Jim Piavis, Bob Waldmiller, and Vern Blomquist, all of whom work for the B-2 Combined Test Force, got to talking about their homebuilt airplane projects. Piavis, a maintenance supervisor, is building a Boredom Fighter, while Waldmiller and Blomquist, both flight test engineers, are building craft of their own designs named Excalibur and Kiwi—the latter named after the flightless bird of New Zealand because even Blomquist isn't sure it will ever get off the ground.

They started counting up how many other guys on base were building their own airplanes and came up with eight, who were building everything from a BD-5 to a Glasair II. Enough, they figured, to form their own chapter of the Experimental Aircraft Association.

And what a chapter it would be. Thirteen years ago, in *The Right Stuff,* Tom Wolfe described the early occupants of Edwards, back when it was called Muroc Field, as "some sort of weird ribald aerial tarpaper mad-monk squadron up on the roof of the desert." Though none of these modern mad monks takes offense at Wolfe's description, Waldmiller prefers the term "true believers." In any case, the EAA was so taken with the prospect of an Edwards-based addition that it reserved number 1000 for the Muroc chapter.

Word spread quickly, and now about 25 people show up for the monthly meetings. The ranks have swelled to include electrical engineers, test pilots, and the new vice commander of the Flight Test Center. And last March, Scott Horowitz, one of their own, first flew his Tri-Q-200 and was also chosen by NASA as an astronaut.

As might be expected, a certain amount of trickle-down technology appears in their projects. Waldmiller's Excalibur, for example, started as a Corby Starlett. But one better idea led to another until "the only thing they have in common now," says Waldmiller, "are nine control surface hinges. Everything else is my own."

Ideas really start to fly during post-meeting gatherings at the base's Burger King, a site chosen because "it has bigger napkins." Here members exchange admittedly "wild-ass" ideas ranging from an ultralight-moped conversion to a homebuilt single-seat, single-stage-to-Earth-orbit transatmospheric vehicle. It's a good thing the cold war is over, or the first order of business for the Muroc EAA might have been designing a napkin/document shredder for Burger King.

—Elaine de Man

Midway's Tag Sale

It was a fitting day for a wake, overcast and unseasonably cold. You could see your breath in what had been Midway Airlines hangar no. 1 as auctioneer Ron Gray took the podium and announced, "We are going to sell rapidly, gentlemen. Keep your bidder paddles handy."

Surrounding Gray and spilling into two other hangars was what remained of the Chicago-based airline that went under last November: rows of hand tools, hydraulic jacks, ladders and lubricants, a sea of desks, lockers, molded plastic chairs, and stacks of arrival/departure boards, even a crate of Tampax—everything needed to run an airline except the airplanes, which had been mothballed in the Arizona desert. In all, some 2,500 lots of merchandise were sold over three days last April, drawing 2,000 bidders from as far away as Anchorage.

A mostly male crowd of 200 from other airlines, machine shops, parts warehouses, rental companies, airline maintenance and distribution firms, and even neighboring South Side businesses huddled for the opening gavel. Many had tape measures or bundles of keys on their belts and Bulls or White Sox caps on their heads. A Chicago cop took notes as he cast a critical eye on a row of Frisk 'Em 700 metal detectors.

After a couple of hours the auction

moved outside, where a fleet of vans, trucks, carts, towbars, and baggage tugs sat rusting in the damp Great Lakes air. The first two items, a pair of maintenance platforms, went for just $20 each. "C'mon, you're falling asleep out there!" Gray complained.

"There's no bargains here as far as we're concerned," a TWA executive said afterward over the roar of departing jets. "We bought some lav trucks but that's about it. They wanted $30,000 for that tractor we just bid on."

That drew a laugh from Mike Koscielski, a former Midway employee who had come to bid for a general contractor. "TWA's gotta be frugal—they're in bankruptcy," he said. "You don't see United or American out here. They don't need this junk." His harsh words belied his fondness for his old employer. "I never thought I could feel like this for a company," he said. "We didn't expect to go belly-up, and it hurt. This place was always like family."

By the end of the auction, the family heirlooms had been sold for $2.5 million. Koscielski outbid an asphalt company for some lane-marking equipment. "Here I am spending $1,800 and I've got four dollars in my pocket," he said with a knowing glance at Alex Strelczik, an unemployed Midway mechanic who had come to commiserate. "C'mon," Strelczik said. "I know where we can get some happy hour beers for 50 cents."

—Frank Kuznik

Update

Ejection Seats Nixed

A new Federal Aviation Administration policy on the certification of civilian-owned surplus military aircraft ("Happiness Is a Hot Jet," June/July 1992) states that "ejection seats, if so equipped, are disabled" and that "[i]n no case will jettisonable external fuel tanks be permitted."

Strange Brew

When the shuttle *Discovery* lifted off last January, it had, officially, 42 experiments to conduct. But thanks to a Canadian pub and avid homebrewer-astronaut Bill Readdy, a 43rd experiment was added at the last minute: a study of the effect of zero gravity on hops.

Readdy smuggled aboard about nine ounces of hops, bought at a Houston homebrew store, and slipped them into the fresh food locker. They were almost eaten during the flight by a fellow astronaut who, apparently bored with his own rations, wanted to sample the "green leafy stuff" in the plastic bag.

After the shuttle landed at Edwards Air Force Base in California, the hops were sped by courier to Spinnakers Brew Pub on Vancouver Island, British Columbia, where Brewmaster Jake Thomas was waiting to include them in "Discovery Ale: A Taste Worthy of Those Who Dare to Explore." Weeks later, Readdy and the rest of the crew showed up for a taste. Aside from an entourage of 30 or so from NASA and the Canadian Space Agency, only a select handful of beer connoisseurs from Campaign for Real Ale, Victoria chapter, and a few bewildered tourists witnessed the event.

Stepping behind the bar, Readdy drew the first glass of Discovery Ale, rapidly quaffed a few mouthfuls, caught the drips on his NASA rugby shirt, and proclaimed, "I declare this ale fit for human consumption!"

It certainly was. The full-flavored amber ale drew both scientific and spiritual acclaim as the cask was drained in the time it takes to climb out of a spacesuit.

Discovery Ale certificates, signed by the brewmaster and the Spinnakers proprietor, were handed out to the



JOHN ROWLING

astronauts and the rest of the samplers. In exchange, the pub received a large color photo of the Kamchatka peninsula taken during *Discovery*'s flight.

—Dave Preston

Update

The crate that carried the *Spirit of St. Louis* back to New York after Charles Lindbergh's Atlantic crossing has been made over into a mini-museum in Canaan, Maine (Soundings, June/July 1990). Larry Ross, who paid $3,000 for the dilapidated box in 1990, orchestrated an elaborate dedication ceremony for the May 21 opening, including several flyovers, 150 guests, and a proclamation from the governor commemorating Lindbergh Crate Dedication Day.





RICHARD SASSAMAN (2)

Standing Down

Some military units die young, destroyed in battle. Others dodder on long after their time has passed. But some are erased by the absence of threat, as was squadron VFA-132, based at U.S. Naval Air Station Cecil Field outside Jacksonville, Florida.

The May 15 disestablishment was not the squadron's first such ceremony. The fortunes of VFA-132 ("V" indicates fixed-wing aircraft; "FA," fighter-attack) have fluctuated since the unit was created in 1945. Nicknamed Privateers after the civilian sailors who fought for the fledgling republic during the American Revolution and the War of 1812, the squadron flew F4U Corsairs until the

Navy disbanded it in 1949. During the 1961 Berlin crisis VFA-132 re-formed and took to the air in F8U Crusaders. Fourteen months later it broke up again but was reborn in 1984 when the Navy introduced the F/A-18 Hornet. VFA-132 flew F/A-18s off the carriers *Forrestal* and *Coral Sea* (from which the briefing board and chairs in the squadron's ready room were salvaged)until peace broke out and a budget-driven Navy decided the squadron's airplanes, pilots, and crews would serve best dispersed among other units.

The ceremony, held before the June 1 disestablishment deadline so that pilots and crews could attend before shipping out, was short and bittersweet. In Hangar 825 stood Commander John L. "Flamo" Fleming's Hornet, the last one to bear VFA-132's markings; it would be repainted within days. A Navy band was to have played, but arrangements fell through at the last minute, forcing VFA-132 to scrounge up a cassette player and a tape by the Cars, along with some brassy marches. The music yielded to conversation and the whirs and clicks of video recorders and camera shutters, all of it obliterated when an F/A-18 from another squadron roared overhead.

With a series of chimes on a ship's bell and a trill on a bosun's pipe, officers filed onto the stand. A color guard moved through its paces, the chaplain delivered an invocation, and each officer spoke. Then came Flamo Fleming's turn.

The others had addressed the fate of a military in the grip of peacetime economics; the captain thanked his family for their forbearance, remembered a former Privateer who had died in a crash, and praised the airplanes his squadron had been flying. "All you have to do is fly it to love it," he said. "The F-18 will carry the U.S. and the Navy into the next century in fine style." Fleming spoke of the squadron's safety record, the perfectionism of the maintenance crews, and the squadron's 280-plus days away from home base last year. He distributed bouquets to wives who had served as family ombudsmen during the Gulf war.

The sky clouded up as Fleming read the decommissioning orders. His voice snagged, then regained momentum, and he quoted Napoleon on the inevitability of soldiers winning battles only to have the generals get the credit. The sun reappeared in time for the colors to be retired, the executive officer's saber flashed as he dismissed the unit, and in a blink the Privateers of VFA-132 were once more consigned to history.

—Michael Dolan



MUSEUM OF FLIGHT

An example of a new advertising technique called "extensions," which incorporates three-dimensional images, this billboard for Seattle's Museum of Flight recently won an Obie Award for outstanding creativity. (The ad industry Obies take their title from the ancient obelisks of Egypt, considered by the Outdoor Advertising Association to be the forerunner of today's billboards.)

One Country's Trash Is One Frenchman's Treasure

A Soviet Photon satellite fetched a cool million francs ($180,000) at a Paris auction last April in the first public sale of space hardware. Put on the block by a Russian agency that chose to remain anonymous, the two-ton Photon had previously served as a mini-spacelab that flew two-week missions. Before going under the gavel the satellite was exhibited outside the Espace Kronenbourg auction hall on Paris' posh Avenue Georges V, causing some passersby to wonder what strange new auto had taken their parking places.

Strange indeed, since the Photon was completely scorched from its last flight in April 1990 and branded with a skull and crossbones, presumably a warning of hazardous materials it had once transported.

The bargain-basement price drew no aerospace companies, space organizations, or museums. Its buyer was Frenchman Georges Lancelin, who owns a group of rope and textile factories. He displayed his purchase at the Euro Satory land defense equipment show at Le Bourget airport last June, and plans to stump the supermarket circuit, renting the satellite to Gallic stores everywhere. "I want to help explain space technology to kids," he says. Aside from the educational motive, why did a factory owner buy a used satellite? "It's my birthday," he says. "A million was my absolute limit, though."

—Joshua Jampol

Update

New Reconnaissance Agency

The Pentagon has created the Central Imagery Office to streamline satellite imaging operations and intelligence gathering ("The Spies in Space," December 1991/January 1992). Largely a result of operational shortcomings discovered during the Gulf war, the CIO is charged with deciding what to reconnoiter, providing information for all U.S. intelligence groups, and making sure that all the various satellite systems are compatible with one other.

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SCOTT ANDREWS

Endeavour's First Launch...

A road trip through southern Florida reveals how completely America's space program has been assimilated into the culture. Billboards for NASA contractors and local surf shops often share the same stretch of highway, and on the day of a shuttle launch, the "No Vacancy" signs that appear everywhere indicate that Kennedy Space Center is every bit as big a tourist attraction as nearby Sea and Disney Worlds.

Last May a new shuttle made its maiden voyage. It was named after the HMS *Endeavour,* a 98-foot-long wooden ship that had been chartered by Britain's Royal Society to sail to Tahiti to observe the transit of Venus 224 years ago. The maiden voyage of its 20th century counterpart had also been chartered, at least partially, by an international consortium of phone companies. But this *Endeavour* was bound for low Earth orbit and a wayward satellite.

On launch day, the new shuttle and its crew of seven waited at pad 39-B for the weather to make up its mind. Earlier in the day, the odds on a timely launch had been dampened by a rain squall. By late afternoon, astronaut Steven Nagel was airborne in the modified Grumman Gulfstream that serves as a shuttle training craft, zooming overhead every few minutes on a weather check. Skies were clearing, but Launch Control still had a problem: it had started raining at the Morocco landing site that NASA prepares for aborted flights. The countdown was also delayed by a glitch in one of the shuttle's two master events computers, which relay commands to fire charges that separate the solid rockets and external tanks after liftoff.

The new shuttle, probably NASA's last orbiter, had been delivered to Kennedy a year ago, with several new avionics systems and a drag chute to reduce its landing rollout. *Endeavour* can also stay in orbit for up to 28 days, about three weeks longer than most of the other shuttles.

The sun was low in the evening sky by the time the countdown resumed. At 7:40:07 p.m. EDT, white smoke billowed from beneath *Endeavour* as it rose on a column of bright light. It was the third shuttle launch of the year and the 47th shuttle flight in all, but that didn't diminish the cheers. Two minutes later the solid boosters separated and the orbiter continued to climb, a rising star at dusk.

At a post-launch press conference, Daniel Goldin basked in the success of *Endeavour*'s liftoff, his first launch as NASA chief. He'd witnessed lots of launches at the cape, he said, but never before had he been in charge. "I just sat and watched," the new administrator said. "I didn't touch any buttons, as promised."

—David Savold

...and Intelsat's Last Chance

The third and final attempt to rescue the Intelsat communications satellite from its useless orbit last May was the stuff of maximum tension: *Endeavour* inching up to the comsat as the two machines whirled around the globe, the payload bay doors yawning open, the trio of tethered astronauts clambering into position. If they failed, Intelsat, which twice declined to insure the satellite, could wave bye-bye to $250 million for the hardware and launch and $150 million for NASA's rescue effort.

But at Intelsat's home base, a mirror glass fortress resembling a space station grounded in an uptown Washington, D.C. neighborhood, the mission's final hours were a form of exquisite boredom. Outside, TV trucks shoved white antennae into the sky. Inside, canapé-bearing waiters in black tie threaded their way among reporters and Intelsat executives staring at oversize TV monitors showing a pair of NASA managers and an *Endeavour*'s-eye view. On the far side of the brushed-aluminum lobby, cameras and lights were aimed at a bank of small monitors; now and then someone would conduct an interview or deliver an update. At one point the crowd parted to let a pair of employees ferry mini-models of *Endeavour* and quarry to an observation booth overlooking Intelsat's mission control room, where technicians fine-tune the orbits of company comsats.

People at the rows of computers and keyboards in the control room, normally the nerve center of post-launch operations, were lounging around as if



their mainframe had pulled a tendon. In an alcove, a couple of suits were gobbling ice cream bars, leaning forward to avoid dripping vanilla on the worsted.

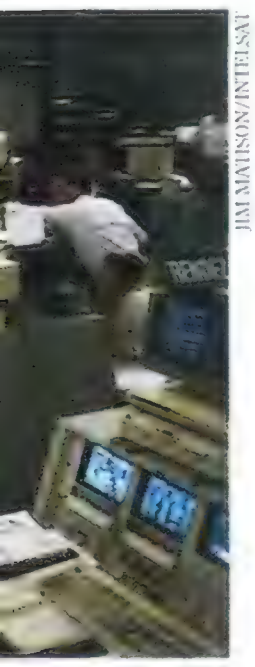
The minutes crawled by as *Endeavour* commander Dan Brandenstein continually announced new and slower closure rates: 14.7 feet per second...9.6 fps...0.4...0.2. A print reporter fell asleep in a swivel chair while camera technicians rehearsed shots and TV reporters practiced their bits.

Then, from the lobby came the announcement that extravehicular activity had been postponed, which prompted two rushes: local TV people headed for the exit, since the delay would keep the event from making the early evening news, and everyone else headed for the buffet tables.

Just before 8 p.m., as dessert was being set out, the screen showed Pierre Thuot swaying slightly in foot harness, just a few feet from one end of the satellite. Like plants responding to the sun, everyone rotated into viewing position. Astronaut Richard Hieb hove into view, followed by Thomas Akers. Conversation ceased. In mission control, half-eaten plates of smoked salmon were set aside while their owners refocused, one eye on a computer console, the other on the big screen.

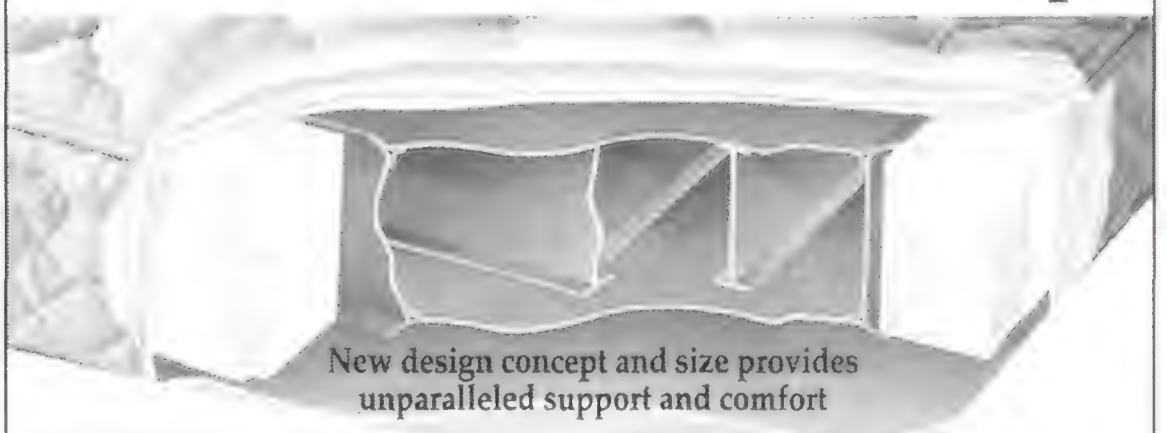
There was a pause to accommodate a microscopic wobble in the satellite, and someone explained that a bad grab would send it in a slow careen to join Major Tom on the edge of the universe. Six sets of pudgy gloved fingers rose in unison: *They've got it!* In the control room, smiles and slumps of relief abounded among cheers. A couple of hours later, when Intelsat VI was attached to the shuttle's robot arm, it was champagne all around.

—*Michael Dolan*



JIM MATISON/INTELSAT

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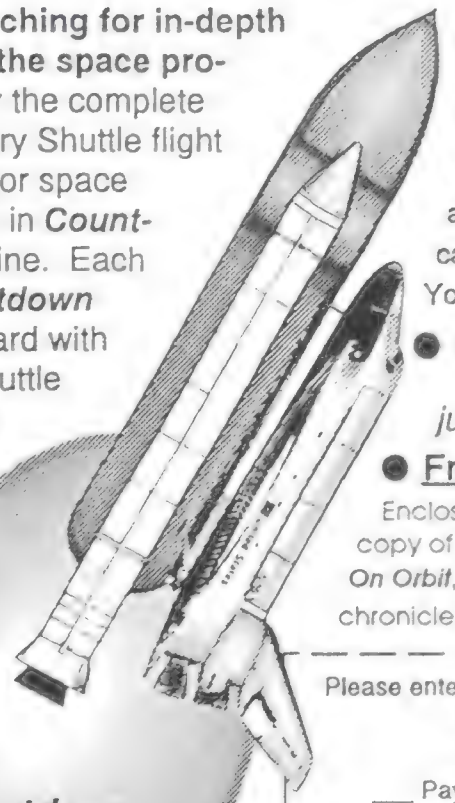
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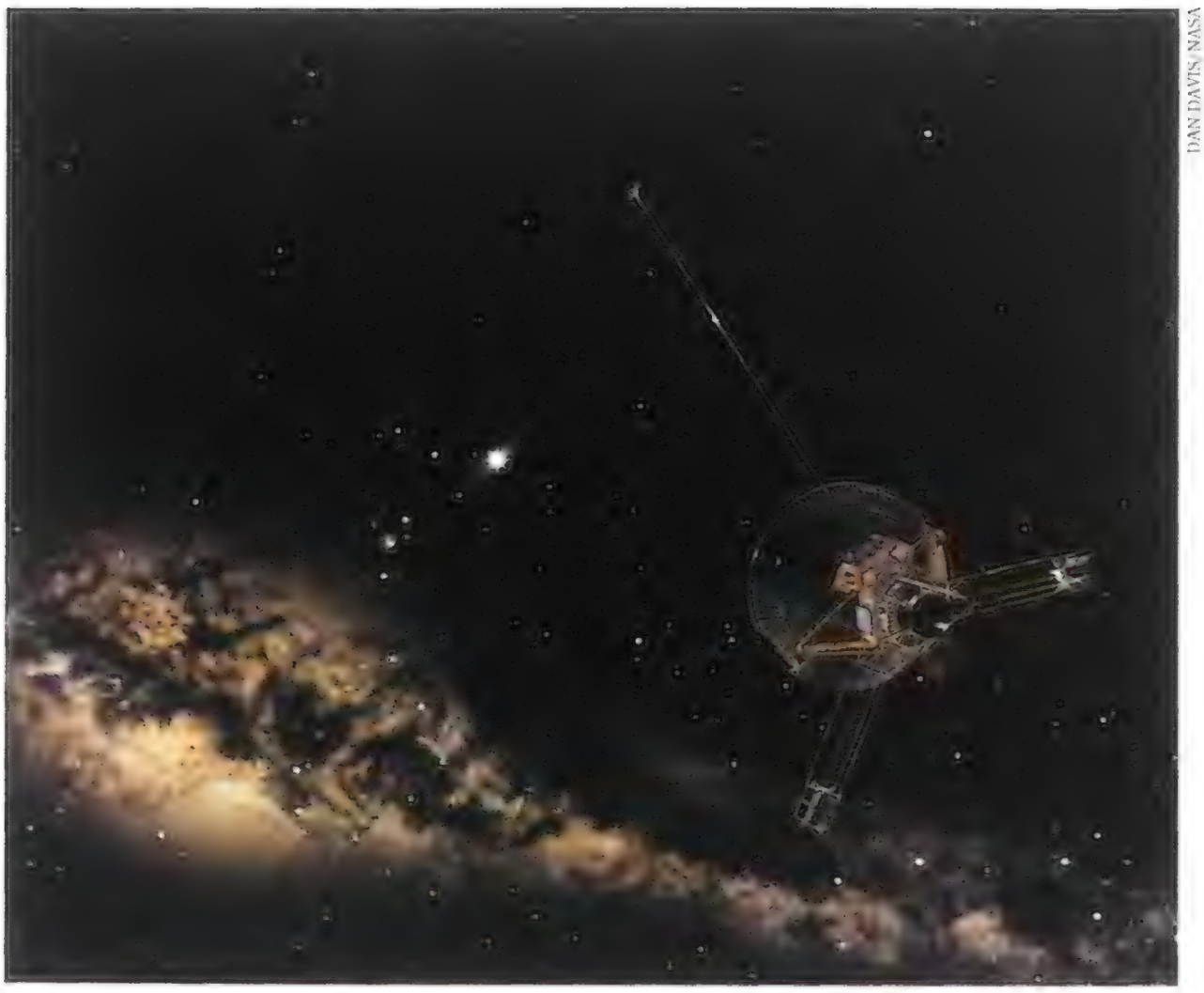
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Outta Here



DAN DAVIS/NASA

Name tags and gray suits filled the Pioneers of Flight gallery on the evening of June 2, when members of the space community gathered at the Museum to celebrate Pioneer 10's 20th anniversary. Launched on March 2, 1972, the spacecraft has traveled some 5.3 billion miles from Earth. On June 13, 1983, Pioneer 10 became the first man-made object to travel beyond the outermost planet in the solar system.

Most of the guests at the celebration were from NASA's Ames Research Center, which still manages the Pioneer project, and from TRW in Redondo Beach, California, where the space probe was designed and built. As a classical guitarist played nearby, they congratulated one another on Pioneer 10's accomplishments, especially proud since the 577-pound spacecraft was designed for only a 21-month mission to Jupiter. "I'd like to say that we're not surprised that an aging, comparatively primitive spacecraft is still working, but I can't," marveled Gordon Williams, head of TRW's space and technology group. With Pioneer 10 still returning data, the people on the Pioneer team are hoping that it will beat Voyager to become the first spacecraft to leave the heliosphere—the vast bubble of solar plasma that, with the sun's magnetic field, envelopes the solar system—on its journey into interstellar space.

At 8:00 sharp, everyone convened in the Museum's movie theater for a series of speeches. NASA administrator Daniel Goldin, a former TRW executive, spoke of the need to return to the precedent set by Pioneer 10: small, simple, low-cost spacecraft. "Building spacecraft didn't take so long then," he said of space exploration's golden age. "We can't let grad students turn into senior citizens while they wait for launches." When he mentioned the possibility of imaging planets around other stars, he got off the evening's best line: "We don't know what we don't know." His down-to-Earth style contrasted with other speeches in the program, which were filled with phrases like "characteristic spectral absorption lines" and "dipole-like asymmetry."

The evening's stellar guest was James Van Allen, the scientist for whom the radiation belts encircling Earth are named. Van Allen reminisced about the early days of Pioneer 10's journey, when "fresh discoveries were pouring out of our little cubicles on a minute-by-minute basis." Then he turned his attention to the probe's current investigations. With seven of its 11 instruments still working, Pioneer 10 is returning data on solar wind, cosmic radiation, gravity waves, and the possible existence of a 10th planet. Van Allen expressed his great hope that Pioneer 10 will pass out of the heliosphere and into the interstellar medium before its nuclear power supply runs out.

—Diane Tedeschi

Little Bitty Neutral One

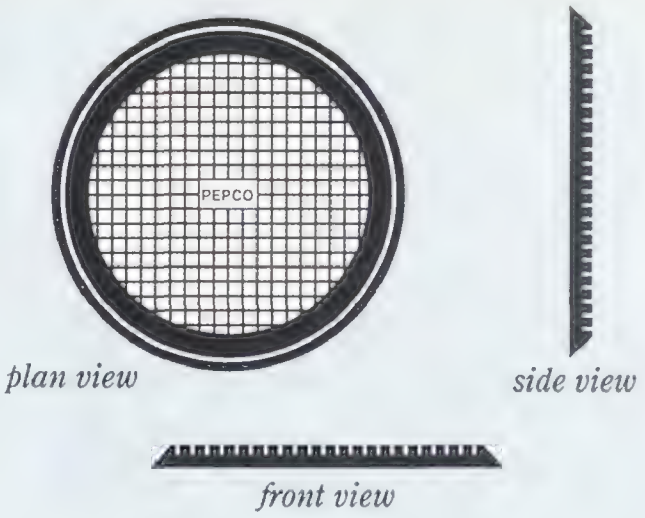
Most of the slides projected onto the dome of the Albert Einstein Planetarium and appearing over the right shoulder of astrophysicist Virginia Trimble as she addressed the audience were notes jotted in Trimble's handwriting. Obviously a lecture about invisible particles won't have a big show-and-tell component. But Trimble did manage to find a few pictures to emphasize the points she made about the neutrino, the elusive subatomic particle produced when a neutron is smashed or simply falls apart. Coined by physicist Enrico Fermi in the 1930s (about 20 years before the first neutrino was detected), the word "neutrino" is Italian for "little neutral one." It is a high-energy particle with no electric charge.

Neutrino astronomy is one of the more esoteric topics in the Exploring Space lecture series the Museum sponsors.

And Outside the Museum

It might have been an audition for a place in the Vertical Flight gallery, but it didn't work. Although the newspaper headline read "Explosion sends manhole covers flying near air museum," the three manhole covers that flipped near the Museum entrance last May as the result of an explosion in underground electrical cables didn't fly very far.

"First of all, we like to refer to them as 'utility vault covers,' " says Steve Arabia of the Pepco power company. "And they weigh between 100 and 150 pounds, so 'flying' isn't exactly what they do. They sort of rock or come ajar."



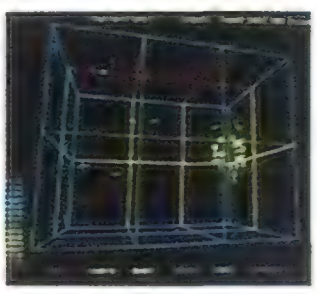
For interested visitors, the manhole covers will remain on exhibit where they have always been, on the sidewalk along Independence Avenue.

Neutrinos, explained Trimble, a professor at the University of California at Irvine, have bad and good qualities for the scientists trying to study them. Unlike photons, neutrinos only rarely interact with any other particles. This makes them almost impossible to detect; "on the other hand," Trimble added, "they will come to you from long distances." Neutrinos travel at the speed of light, or nearly so, unimpeded by clouds, atmospheres, planets, or lead shielding. Neutrinos pass through everything, including you and me—billions of them a second.

Trimble showed a computer graphic representing the evidence of a neutrino's trip through the Irvine-Michigan-Brookhaven (IMB) detector, a tank holding 7,000 tons of highly purified water a half-mile underground near Lake Erie in Ohio. For every 100 trillion neutrinos that zip through undetected, one will bump into an electron or proton and transfer its energy, an interaction that 2,000 light detectors are on guard to record.


NATIONAL GEOGRAPHIC SOC.

IMB detector


HENRY W. SOBEL

Neutrino tracks

The event that Trimble's slide symbolized occurred in February 1987, when a supernova 160,000 light-years away in the Large Magellanic Cloud bombarded Earth with 10^{28} neutrinos. Fewer than 30 were detected worldwide, although there is disagreement among scientists about the exact number. This scarcity places neutrino astronomers in the same boat with early gamma-ray astronomers. "At one point in the history of gamma-ray astronomy," Trimble told the audience, "the number of papers published was much larger than the number of gamma-rays observed."

Physicists are interested in neutrinos not only because of what they may tell about the nuclear processes within stars, but because the particles are also candidates for the universe's dark matter, which astronomers have yet to define.

Besides Supernova 1987A, the only extraterrestrial source of detected neutrinos is the sun, another photo op for Trimble. She showed a slide of the sun eclipsed by the moon, pointing out that "the fact of having the moon in front makes not the slightest difference." Neutrinos charge right through.

—Linda Shiner

The Jug

The pilots who flew the Republic P-47 Thunderbolt in World War II think their airplane has gotten a bad rap. Saddled with the reputation of being all brawn and no brains, the Thunderbolt is often portrayed as a big dumb jock that got through the war on the equivalent of a football scholarship. The *real* American fighter of World War II, most histories explain, was North American's compact P-51 Mustang.

Many P-47 pilots believed that this attitude was what kept the Thunderbolt out of the National Air and Space Museum. Says Henry Lederer, a member of the P-47 Pilots Association who flew the Thunderbolt for the 374th Fighter Squadron of the 361st Fighter Group, "I have no idea why the Museum did not recognize the airplane, other than the fact that the P-51s are a beautiful airplane and the public relations that went with the P-51 seemed to obscure the P-47. The P-47 was first over there and did the major job, had more victories."

"We can understand the problems they were having because [the P-47] is so large," conceded Emerson Berical, an association past president. "They couldn't put it up with the regular World War II aircraft because it needed so much room."

Lederer, Berical, and many of the 2,000 members of the P-47 Pilots Association had been after the Museum since it opened to display a Thunderbolt, and this year they finally got what they wanted. Last May the P-47 was officially unveiled as the first aircraft in an exhibit series titled "Air Power in World War II." It will be on display in the Special Aircraft Exhibit area on the first floor for a year, and then will be replaced by the German Arado 234 jet bomber.


NASM

Though it was designed as an interceptor and used as an escort fighter, by the end of World War II the Thunderbolt, known affectionately as the Jug, was primarily a fighter-bomber, and pilots began adorning their aircraft with silhouettes of the locomotives and trucks they had destroyed, as well as enemy aircraft. "The way it ended up being used was sort of an accident," says Mike

Artifacts



The spidery legs of the Apollo lunar module are piston-cylinder struts designed to compress up to 32 inches in order to absorb the impact of a 10-foot-per-second vertical landing. One strut was equipped with a nine-rung aluminum ladder for the historic descent to the moon's surface, portrayed in the display at the Museum's east end.

The shock absorbers must have worked pretty well. This is how astronaut Buzz Aldrin remembered the landing: "It was strange to be suddenly stationary. Spaceflight had always meant movement to me, but here we were rock-solid still, as if the LM had been standing here since the beginning of time. We'd been told to expect the remaining fuel in the descent stage to slosh back and forth after we touched down, but there simply wasn't enough reserve fuel remaining to do this." The LM landed with 20 seconds of fuel remaining.

Neufeld, one of the exhibit's curators .

As originally conceived, the airplane was supposed to be smaller, powered by a liquid-cooled, in-line engine. But when Pratt & Whitney's 2,000-horsepower R-2800 radial engine became available in 1940, Republic built a much larger airplane around it, armed with eight .50-caliber machine guns. It was a big, solid aircraft. At 10,000 pounds, the P-47D weighed almost half again as much as the P-51D. "It's a more typical American design philosophy," says curator Tom Dietz. "Make it big, make it overwhelmingly powerful, and because you have the industry and resources to produce such an airplane, those sorts of considerations aren't limitations, as they were for the German aircraft industry or even the British aircraft industry."

"It acquired the name Jug from looking like a milk jug," says Neufeld, "but when it got to Britain they translated that into 'Juggernaut.' They thought the thing was so big they asked, 'What are you going to do to dodge the bullets, run around the cockpit?'"

The Thunderbolt had another typically American characteristic—it was a gas hog. Until it was fitted with drop tanks, the airplane had limited range, so when its role shifted from interceptor to escort fighter, its effectiveness suffered. "The end result was to put the P-47 down as a failure because of its lack of range," Neufeld says, "when in fact during the early months of '44 it did a good deal of damage to the Luftwaffe day fighter force. In the end the P-51 was a better escort fighter because of its range advantage."

But Thunderbolt pilots loved the Jug because they could depend on its sheer survivability. "There are a lot of pilots alive that would not be here if they had been flying anything else," says Robert S. Johnson, who scored 28 victories in his Thunderbolt in the skies over Europe. "Jokingly we've often said what we couldn't shoot up we would run through. And there's lots of boys did that. Some of them didn't mean to, but they did."

In his book *Thunderbolt!*, Johnson tells of one mission when a German Focke Wulf 190 attempted to shoot down his crippled P-47. Three times the German pilot lined up on Johnson's tail and raked the American fighter with his machine guns. The German finally gave up, and Johnson managed to fly his riddled airplane home.

A number of loyal P-47 pilots turned up on May 20 when the Museum unveiled its Jug, a P-47D that was used for training and never saw combat. "It should have been here from the first day," said Wayne Dodds, one of the association's past presidents. "It's a wonderful feeling just to see that old monster right up here," said Emerson Berical as he gazed at the Museum's Jug, which is decked out in the colors of the 353rd Fighter Group's 350th Squadron. "It's a big airplane but it did the job. It was a forgiving aircraft. It handled beautifully and above 25,000 feet there wasn't another fighter aircraft either side that could touch it."

—Tom Huntington

Museum Calendar

Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202)357-2700; TDD: (202)357-1729.

August 1 Monthly Sky Lecture: "Volcanoes in the Solar System." Jim Zimbelman, NASM, Einstein Planetarium, 9:30 a.m.

September 17 General Electric Aviation Lecture: Women Airforce Service Pilots (WASPs). Major General Jeanne M. Holm will moderate a panel. Langley Theater, 8 p.m.

World War I Lecture/Film Series

September 11 Film: *All Quiet on the Western Front,* the dramatization of Erich Remarque's novel about a young German soldier's experience of World War I. Langley Theater, 8 p.m.

September 22 Lecture: John Keegan, author of *The Face of Battle,* on military historiography. Langley Theater, 7:30 p.m.

September 25 Film: *Hell's Angels,* an aerial drama directed by Howard Hughes. Langley Theater, 8 p.m.

September 29 Lecture: John Morrow, Franklin Professor of History, University of Georgia, on the impact of the war on the development of aviation. Langley Theater, 7:30 p.m.

Star Trek How to Obtain Passes:

All visitors, regardless of age, must have a pass to enter. Free same-day passes (four per person maximum) may be obtained at the Museum. Advance passes may be obtained for a fee through area Ticketmaster outlets or by calling (800)551-7328. For recorded information, call (202)786-2122.

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Catching Rays



MARGARET SCOTT (2)

After witnessing a total eclipse of the sun in 1806, novelist James Fenimore Cooper was moved to write: "Never have I beheld any spectacle which so plainly manifested the majesty of the Creator, or so forcibly taught the lesson of humility to man…." To anyone who saw the eclipse of July 11, 1991, Cooper's reaction is quite understandable. Who wouldn't be stirred by the looming outline of the moon slicing the solar disc like the hand of a great celestial clock creeping past the zenith? The morning dazzle turning to an eerie, pallid gray? The dramatic moments of totality, when a fringe of crimson prominences springs out against the pearly white of the sun's corona? Who wouldn't feel small, insignificant, humbled?

After viewing four total eclipses, I've discovered they teach you another kind of humility as well. I'm talking about the kind that comes of experiencing Murphy's Law, when the best laid plans go wildly astray and nothing goes as it should. No matter how well one prepares, shutters do not trip, film ceases to advance, something crucial fails to work as well as it did weeks prior. Set against the cosmic precision of the great eclipse itself, the failures seem to be nature's way of thumbing its nose at us.

Ask anyone who's been to an eclipse. Pierre Janssen, one of the pioneers of solar physics, had identified the presence of hydrogen in the solar atmosphere during an 1868 eclipse. In 1870, when another eclipse beckoned in Algeria, Janssen was stuck in Paris, which was blockaded by Prussian troops. Commandeering a balloon, the scientist flew over the armies and boarded a steamer, arriving in Algeria only to find the eclipse blocked by clouds. Thomas Edison, troubled by winds during preparations for an 1878 eclipse, set up observing equipment in a chicken coop, which worked just fine until the last minutes before totality, when an entire flock, fooled by the advancing darkness, flapped home to roost.

The problem is that eclipses are one-shot deals and short-lived to boot. Totality lasts at most only seven and a half minutes, usually far less, so equipment must work perfectly and observers must observe without a hitch. Problems are compounded by the fact that eclipses have a habit of occurring in inaccessible locations. Telescopes and spectrographs have to be set up in desert dust storms, jungle humidity, or monsoon rains.

The July 1991 eclipse, however, promised to be a cut above the ordinary. It was about as long as an eclipse can get, and it passed over plenty of accessible territory, including the dense population centers of Mexico, the sunny resorts of Baja California, and, most importantly for science, the great observatory on Mauna Kea in Hawaii. A small group of astronomers were to have the privilege of using the large telescopes on the summit, where a dozen experiments would be conducted as the sun was eclipsed. The enormous light-gathering power of these instruments made it possible to use the moon's edge like a dissecting knife. As the edge passed across the sun, scientists would map the physical makeup of the solar atmosphere in unprecedented detail.

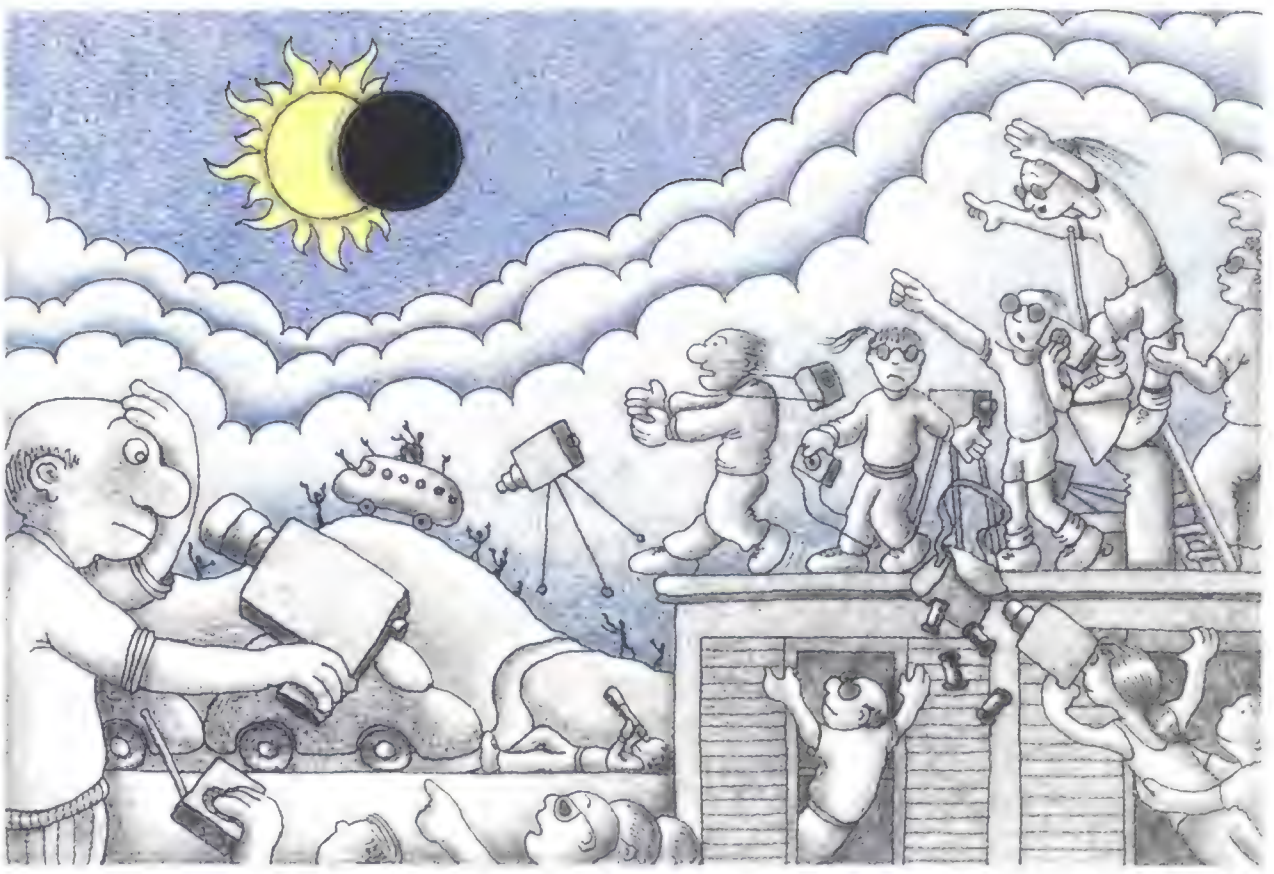
Most of the estimated 40 million people along the eclipse path, however, were content just to experience the thrill of the event and take a few pictures or videos. That was my intention. At past eclipses I'd conducted research on shadow bands—patterns of flickering light that appear just seconds before totality. For this one, I'd left the task of observing to a collaborator and signed on as a lecturer with a tour group headed to Mazatlán, on Mexico's Pacific coast. My family and I, as well as the 135 eclipse chasers on the tour,

looked forward to four days on the beach before the event. On the day of the eclipse some of us would travel 120 miles south to Tuxpan, right in the center of the eclipse path, where totality would be one and a half minutes longer than it would be at our hotel.

From the time our chartered airplane landed—through a thin haze of afternoon clouds—until eclipse day, the question was: Would it be clear at 11:58 a.m. on July 11? And if so, where? Each morning, clouds billowed in from the sea, thinning by noon or early afternoon. Would it be clearer to the south, closer to the centerline? Would there be accessible and open land where one could set up cameras and telescopes? Would heavy traffic along the narrow highway hinder travel? Was it better to stay at the hotel? Speculation was incessant. Every day crowds flocked around the inscrutable satellite photos and ambiguous long-range forecasts posted in the lobby. Some rented cars to scout sites to the south. Others badgered tour leaders for definitive information. But no one, even the most experienced eclipse chasers, knew what the best strategy would be on eclipse day.

July 11 dawned, neither clearer nor cloudier than the days before, and we all made our choices. Most of my group, having read the morning report of possible storms at the centerline, decided to stay at the hotel. We set up our tripods on the terrace next to the pool, pulled up our deck chairs, and waited. Nine a.m...10 a.m...at 10:32, right on schedule, we caught sight of the moon's first bite out of the western edge of the sun. Puffy clouds sailed overhead. To the south, along the coast, we could see a solitary patch of blue. A few anxious souls hailed taxis and headed south in a last-minute attempt to get under the clearing. But we stayed. It seemed that the blue was gradually drifting our way.

As totality approached, it became difficult to tell how much of the gathering darkness was due to the eclipse and how much was due to the uncooperative weather. In the cooling air, clouds seemed to be forming directly overhead. The blue to the south was disappearing. And then, precisely at the forecast time, the eclipse went total. A great cheer went up as the corona shone out through the translucent swirls of vapor drifting above us. For over five minutes we watched the corona brighten and fade behind the overcast layer until a bright sliver of sunlight reappeared on the other edge of the sun. Though the moon wouldn't leave the sun in the clear for another 90 minutes, for most of us the eclipse was over.



But much of the satisfaction—and frustration—of an eclipse is experienced in retrospect, in sharing stories with fellow eclipse chasers. Each person had a different version of those brief minutes. An orthodontist from California, on the roof of the hotel, had seen the shadow of the moon racing toward him across the sea. (We had been facing the other way, alas.) A computer programmer from Manhattan had been impressed with the brilliance of the flame-like prominences seen during totality. Two couples had driven toward the blue, only to find themselves under a cloud during the crucial five minutes. One of the taxi renters had found a patch of clear skies just in time and had viewed the whole thing while lying on a highway median strip. And, wouldn't you know it, the busload that had trekked south into "possible thunderstorms" had experienced the best view of all in the clearest of skies.

We were all humbled, but the humblest of all were those of us who had expected the most and had come up short. Those who had chosen to stay rather than go south. Those who, like me, discovered that they'd forgotten to push the record button on the camcorders during the last minutes of the eclipse. Those who had completely missed totality. We drew a perverse comfort from news that many of the tour groups in Hawaii had been clouded out, and that even the telescopes on Mauna Kea had not done as well as expected because of high cirrus clouds on the peak and dust from the Mount Pinatubo eruption in the stratosphere.

"Nature is subtle," Einstein reputedly said, "but she is not malicious." Maybe the clouds that half-hid the sun were just the luck of the draw. But at sunset that evening it seemed that nature—or Lady Luck—had to get in one more lick.

Seasoned observers of sunsets report a startling green flash, an iridescent flicker of light, sometimes seen just as the sun disappears over the horizon, especially if it's very clear. While not as infrequent as eclipses, the visibility of the green flash is hard to predict. Every summer for the last six years my family and I have trekked out to a Cape Cod beach in hopes of seeing the elusive flash. My children, I fear, had come to regard it as their astronomer daddy's equivalent of the Tooth Fairy.

They know better now. On the evening of the eclipse I was standing on the hotel steps, watching a fierce orange sun sink into the Pacific. *Now* it was clearing, I remarked to a professor of psychology who claimed to have seen the green flash many times from his home in La Jolla. "It looks like good weather for it," he said. "Keep your eye on it." I walked across the patio, gesturing to my family to stand up and look to the west. I caught my daughter's eye. Then a cry went up from people standing near the edge of the patio. "The green flash!" We looked up, already knowing it was too late.

Well, there will be other sunsets, other green flashes, other eclipses. I'm already planning our next eclipse trip, to Chile, on November 3, 1994.

—Laurence A. Marschall

Random Sightings

From Moonwalker, *a memoir by Apollo 16 astronaut Charlie Duke and his wife Dotty (Oliver-Nelson Books, 1990)*:



A trip to the moon was no financial bonanza.... Astronauts are paid according to their military rank or their civil service pay grade.

However, we did get a little extra; a trip to the moon was considered TDY (temporary duty). The per diem or daily rate for TDY at that time was $25 per day. To claim credit, we had to fill out an expense report or travel voucher. My itinerary read: Houston to Kennedy Space Center, Kennedy Space Center to moon, moon to Pacific Ocean, Pacific Ocean to Houston.



The moon trip lasted eleven days, so at $25 per day, that equaled $275 extra money. However, government quarters and meals were furnished, and so they deducted that part. I believe we ended up with $1.25 per day for the trip.

From the safety briefing card placed in the seatbacks of United Airlines airplanes:



If you are sitting in an exit row and you cannot read this card or cannot see well enough to follow these instructions, please tell a crewmember.

From "Suggestions for Anticipating Requests Under Freedom of Information Act," an undated and unsigned NASA document obtained by Congressman Howard Wolpe of Michigan last winter (the Freedom of Information Act entitles citizens to obtain copies of most documents produced by the federal government):



At the conclusion of meetings or at the end of the day review your notes and consider whether you really need to retain them. If you do, take time to rewrite them in such a way as to minimize any adverse impact should they be publicly disclosed. Then destroy your old notes.

...since there is no obligation under [the Freedom of Information Act] to provide documents in any particular order or relationship to each other, furnishing out of context copies of stick-ons [e.g., Post-It notes] can render any information released significantly less meaningful. In this regard, printing rather than writing in script also generally makes it harder to assign authorship (and context) to a particular note or document.

Attempt to make each document (i.e. page) stand alone. Avoid cross references to other documents that can lend context to a document and thereby enhance its informational value should it ultimately be disclosed.

From an advertisement by Iacobucci Metalworkers ("Making carts is what we do—and we do it best!"):

What makes the warm smile, the graceful charm, and the friendly personality of a flight attendant possible? The basic tool of a flight attendant on board an aircraft is the different galley carts and their working relationship with them. Even the slightest problem with a cart causes the flight attendant problems, grief, frustration, and aggravation. The warm smile is gone and the graceful charm disappears, which directly affects the passenger, and their loyality [*sic*] to your product.



From a letter to Air Line Pilot *magazine (October 1991)*:



I went through security in Chicago O'Hare; two men did not. When I questioned the supervisor, I was told they were the government with weapons. Their bags were not searched, and their persons were not searched. I thought my bags were being searched in case someone else planted a bomb in them. Why does this not apply to the government? When I spoke to the supervisor, he immediately demanded my name and number. Does this sound like Communism? This is true, and it happened April 15.

S/O Stephen J. Vella (United)

From the tabloid Weekly World News, *May 26, 1992*:



A passenger plane that vanished on a flight from Rio to Havana in 1939 landed at an airport in Bogota, Colombia, with 36 skeletons aboard last week in one of the greatest aviation mysteries ever!

Even eerier, investigators found cups of steaming coffee and a smoldering Old Gold cigarette...when they flung open the doors of the gleaming 53-year-old aircraft—which was littered with freshly published newspapers dated April 16, 1939....



At least one paranormal researcher is known to be assisting in the investigation. Queried by reporters, Dr. Gloria Hernandez conceded that the plane might have flown through a time warp.... But she was quick to add that the deaths of the passengers and crew suggest an extraterrestrial connection. "If the plane flew through a time warp you would expect the passengers and crew to have remained alive. In fact, they shouldn't have aged a day," said the expert.

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Debra K. Minor, Orlando Sentinel, 10/31/91

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Bob Maschi, Baseball Card News, 11/25/91

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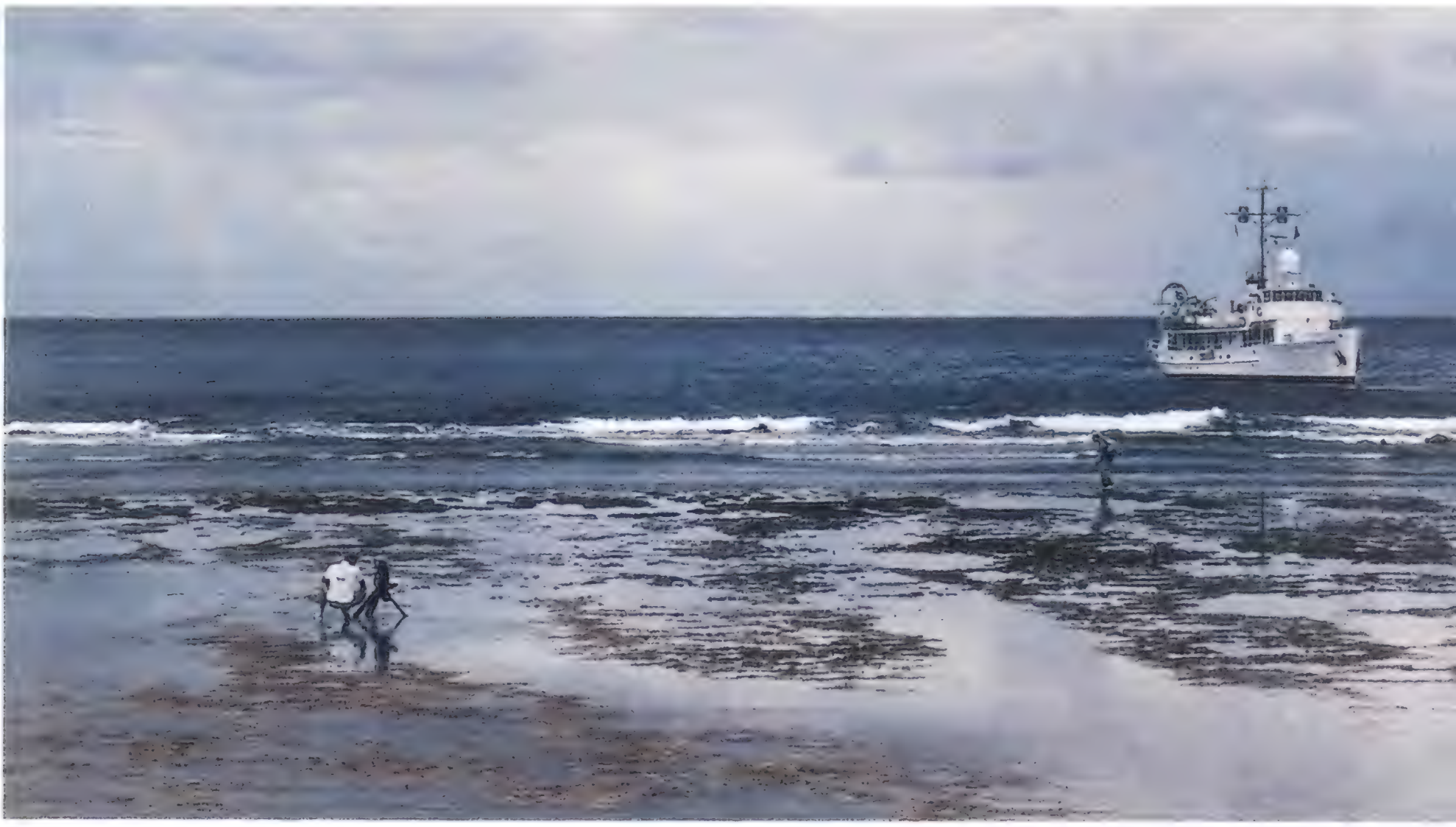
This is how it might have happened.

AMELIA EARHART: IS THE SEARCH OVER?

Why one organization thinks it has solved the mystery.

by Stephan Wilkinson

Photographs by Patricia Thrasher/TIGHAR



Convinced that Earhart perished on Nikumaroro, a TIGHAR expedition returned from the atoll last October with tantalizing clues and plans to go back for more in 1993.

She was terrified. Not yet panicking, but flushed with the hot wash of fear known to any pilot who has had to declare an emergency. Her vision tunneled, time slowed, and the simplest mental tasks became baffling. Amelia Earhart was lost. Big-time lost. Howland Island, a speck of coral in the middle of the vast Pacific, was nowhere in sight.

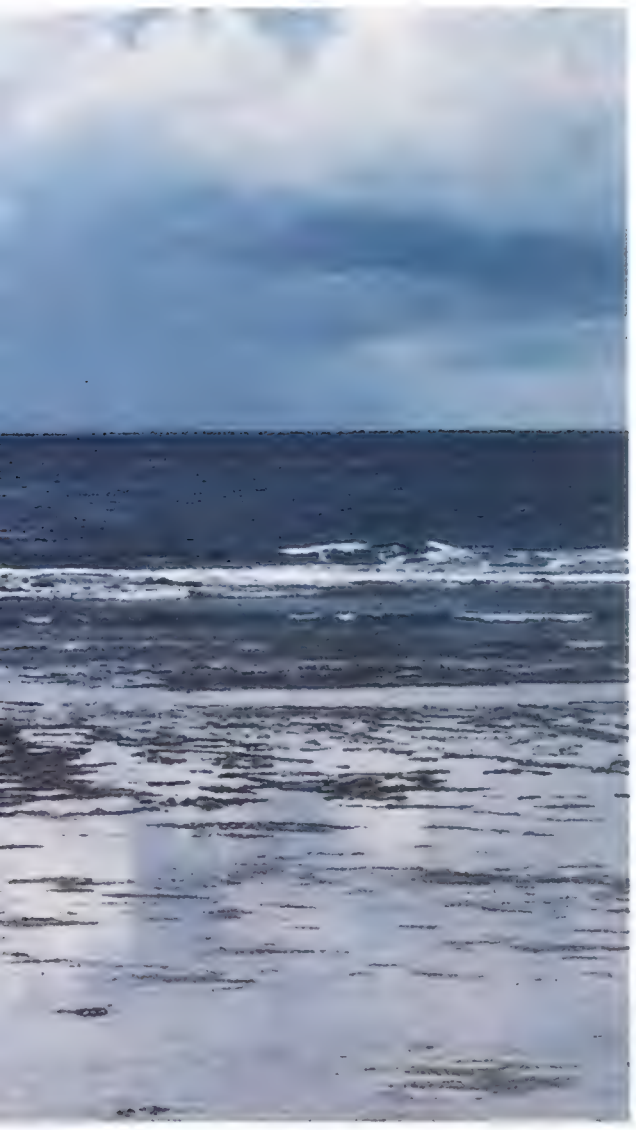
The thin man with the receding hairline in the right seat of the twin-engine Lockheed 10E Electra was scared too, but navigator Fred Noonan was...well, less lost. He had been shooting the morning sun, and though the results couldn't give him a specific location, they provided a line of position, a circumferential line around the earth somewhere upon which Howland Island was located.

When Noonan's octant indicated that the Lockheed, heading northeast, had reached a line of position that cut the compass at 157 degrees to the southeast and 337 degrees to the northwest, he knew that Howland was either to the left on a course of 337, or to the right on 157. They had to be close, since the Coast Guard cutter *Itasca,* waiting at Howland, could clearly hear their radio calls.

If Noonan and Earhart were already north of Howland and turned left, their first landfall would have been the Aleutian Islands; they might as well have tried for Mars. However, if they turned right, to the south, they'd stumble across Howland, or, if they were already south of it, they'd eventually hit Gardner Island, another tiny atoll some 400 miles downrange.

We can only guess what wind correction Noonan fed into the heading he gave Earhart. But we can be confident that Noonan was practicing exactly what he'd been taught at the Weems School of Navigation. He was "running on the line," the standard technique for saving an off-course navigator's bacon. Earhart's last transmissions to the *Itasca* prove it: "We are on the line 157 337. We are running on line."

It cost them nearly three hours of visceral terror, staring through the hot windshield at a bleak, monotonous ocean, Noonan continually updating his sun sights, Earhart desperately willing an islet to appear. Finally, praise be, one did: Gardner Island, the reef-ringed





BALTIMORE AMERICAN—*A Paper for People Who Think*

Navy Planes Halted By Storm In Search For Amelia, Noonan; Fears Grow

ROUTE OF EARHART FLIGHT

Storm Turns Back U. S. Planes In Search For Miss Earhart

WIRE NEWS IN BRIEF

NATIONAL

When Earhart disappeared on July 2, 1937, she immediately became front-page news (above). For the next two weeks, the Navy combed a vast stretch of the Pacific for her Lockheed 10 Electra (right)—or pieces of it—but found no trace.



bottomless, but in any case it would mean ditching, and the Lockheed might flip on touchdown.

But the reef flat—the coral plateau that surrounded the whole island—was an immense runway, in places nearly four miles long and 600 feet wide. The tide was low and the flat was high if not quite dry. Pocked with waterlogged depressions and studded with coral heads, the surface was perhaps jagged enough to shred the airplane's tires. But for a forced landing in the middle of the Pacific, it was a dream.

Earhart got the Lockheed down and stopped. Perhaps a tire blew and the airplane ground-looped, which may have collapsed at least one landing gear. Perhaps Earhart or Noonan, or both, were injured during the landing. But apparently the airplane was in good enough shape that the right engine could be run and its generator used to charge the craft's batteries, for during the next three days, what was assumed to be Earhart's radio was heard 15 times. Pan American Airways, lords of the Pacific, heard the weak transmissions at their Honolulu, Wake, and Midway stations and took approximate bearings on the signals' source, three of which led to the vicinity of Gardner Island.

Soon the U.S. Navy took up the search. One of the three floatplane pilots who circled and buzzed the island on July 9, Lieutenant John O. Lambrecht, reported "signs of recent habitation." But the waves of an enormous storm to the north would have by then beaten the airplane to pieces and scattered them.

Perhaps Noonan and Earhart were standing unseen on the beach waving—any pilot will confess the difficulty of spotting people or objects from the air. Perhaps they were half-dead from injuries. Or dead from dehydration. Perhaps they were on the other end of the atoll today known as Nikumaroro, and still as devoid of fresh water and human life as it was on July 2, 1937.

The beach, Earhart could see, was narrow. It slanted steeply uphill to a dense jungle. It was impossible to tell how soft it might be, but landing on it would obviously be difficult.

The entire core of the island was a placid lagoon about three miles long. No telling whether it was knee-deep or island. No matter, there was nothing left for Lambrecht to identify. "Repeated circling and zooming failed to elicit any answering wave from possible inhabitants and it was finally taken for granted that none were there," he reported. Case closed.

Since then, Amelia Earhart has been spotted everywhere from Saipan to supermarkets, where tabloids perennially report her alive and well in the Japanese

Imperial Palace or suburban Ohio. Yet Richard E. Gillespie, executive director of The International Group for Historic Aircraft Recovery, is convinced she and Noonan died, rescuable yet abandoned, on Gardner Island.

Founded in 1985, TIGHAR is a nonprofit foundation run by Gillespie and his wife, Patricia Thrasher, president of the group. Though TIGHAR has 825 members and several major benefactors—"it's the way archeology always has been," Gillespie says; "We're supported by patrons, not corporations"—its core is the obsessiveness of Gillespie and Thrasher, who draw minuscule salaries from the foundation and devote most of their ramshackle Wilmington, Delaware house to TIGHAR's upkeep.

Much of their work in the past years has involved the search for *L'Oiseau Blanc*, the huge biplane in which Frenchmen Charles Nungesser and François Coli may have crashed in the woods of eastern Maine after crossing the Atlantic nonstop nearly two weeks before Charles Lindbergh's flight (see "The Search for *L'Oiseau Blanc*," February/March 1987). The last thing TIGHAR needed on its plate was the pursuit of aviation's Holy Grail—Amelia Earhart's Lockheed.

But in April 1988, two TIGHAR members, retired airline and military navigators Thomas F. Gannon and Thomas A. Willi, wrote to Gillespie and Thrasher and explained their line-of-position theory, which pointed inexorably to Gardner Island as Earhart's forced-landing site. "We...have yet to see any evidence that she is anywhere but at the bottom of the Pacific," Thrasher responded. Several months later Gannon and Willi arrived in Wilmington. Bearing armloads of charts, graphs, and computations, they set about changing Gillespie's and Thrasher's minds.

In 1989 and '91, well-equipped TIGHAR teams made the long trek to Nikumaroro and returned with evidence and artifacts that can easily be interpreted to support the line-of-position scenario (see "Found Objects," p. 33). But Gillespie triggered a controversy by announcing at a press conference in Washington, D.C., last March that the Earhart mystery had finally been solved—that the recent expedition had returned with what were obviously the heel and sole of Earhart's right shoe and a piece of her airplane's belly skin.



During the nine-day journey from Honolulu to Nikumaroro, TIGHAR expedition members mapped out their search strategy (above). Upon arrival, they found that 50 feet of shoreline—and any clues it may hold—had been swept inland by a storm since their 1989 search (right).

To this day an Earhart industry exists, and many of its entrepreneurs doubtless fear that the revelation will make their books and what Gillespie calls "Japanese man take white woman Saipan" theses look ridiculous (see "The Earhart Mythology," above). Perhaps some are wary of the rather scholarly approach that TIGHAR takes in researching and documenting its findings, for such an intellectual tack is not typical of right-stuff aviation.

Doubtless there are others who imagine Gillespie getting rich off the Earhart mystery. In fact, he and Thrasher are $100,000 in debt to those expedition sponsors who made loans rather than donations. "They just like to take nice trips using other peoples' money," says Jim Almand, a Grand Prairie, Texas physician who owns a restored Lockheed 10 similar to Earhart's. Had Al-

The Earhart Mythology

TIGHAR's premise on the demise of Amelia Earhart is the latest theory to be added to the list. From the tragic to the ridiculous:

- Earhart flew within a few miles of Howland Island but thought she had missed it completely. She and Noonan ditched and died in heavy seas 35 miles northwest of the island.
- Reconnoitering for the U.S. government, Earhart overflew the Japanese navy base at Truk, got lost en route to Howland, crashed at Mili Atoll, and was executed or sent to Saipan, where she died of dysentery.
- Earhart the spy was actually flying a faster and longer-range military version of the Lockheed 10 and either was forced down over Saipan and executed or survived after Noonan's death and returned to the United States after the war with a new identity.
- The 1943 film *Flight for Freedom*, starring Rosalind Russell, popularized the notion that Earhart "got lost" to give the U.S. Navy an excuse to search Japanese-held islands. Sub-theories have her contact the Coast Guard cutter *Itasca*, land at Canton Island, and get ambushed there by the Japanese.

mand talked to the 10 expedition participants, he would have learned of the seasickness many had experienced on the recent voyage between Honolulu and Nikumaroro, and the 10 days they spent chopping through jungle vegetation, excavating likely sites, swinging metal detectors, and sifting sand in temperatures exceeding 120 degrees.

TIGHAR's theory was regarded with suspicion as well, particularly by the media. "I feel like Charles Darwin," he laughs. "Science has proved the theory of evolution, yet there are people who still refuse to believe it." Reaction to the Washington press conference ranged from the *New York Times*' even-handed front-page story, which nonetheless concluded that a "puzzle remains," to a San Francisco newswoman's arch comment that the only mystery remaining was how Gillespie could have been so dumb as to misidentify a piece of metal that wouldn't fit anywhere on a restored Lockheed 10 a TIGHAR critic located at a nearby airport.

In fact, TIGHAR's artifacts are persuasive, and few can be dismissed casually. "Shoes wash ashore all over the Pacific," scoffs Roy L. Stafford, a Jacksonville, Florida restorer of historic military aircraft. True, but the "Earhart shoe" was found a quarter-mile from the beach, on high ground amid thick vegetation. "There are pieces everywhere from two airplane crashes on Gardner during World War II," Stafford also insists. Wrong: a Consolidated PB4Y-1 (the Navy version of the B-24) and a Martin PBM-3D Mariner went into the sea hundreds of miles from Gardner in 1943 and '44, and an unidentified four-engine aircraft crashed at some point on Sydney Island, 200 miles to the east, but no World War II crash ever occurred on Gardner.

There are answers for virtually every objection, and even if one or two artifacts are disqualified, numerous others remain to support the case. For example, after initial confidence that a Consolidated navigator's bookcase recovered on Nikumaroro in 1989 came from Earhart's aircraft, Gillespie is currently questioning its origin. Rather than theorizing that the Lockheed could have contained a Consolidated bookcase, it increasingly seems more logical to conclude that the aluminum box came from a Consolidated aircraft. "You have to be ready to let go of stuff," says Gillespie, who can rarely be faulted for the professionalism of his methodology, "no matter how much time and effort you may have invested in it."

TIGHAR is preparing to launch a third expedition next summer. It will require $1 million, which TIGHAR hopes to gather from members, contributors, sponsors, and patrons. (The two previous expeditions have already consumed $750,000.) "The primary purpose will be to find out what happened to the aircraft," Gillespie says. "We'll also hope to come up with artifacts, but that's secondary.



"We can't rely on another storm to come along and uncover a piece of aircraft skin for us [which is how the presumed belly skin was found during the second search], so the next expedition will be a high-tech search—remote sensing, magnetic-anomaly detecting gear, side-scan sonar, earth-penetrating radar, stuff like that."

Yet there remains the nagging feeling that TIGHAR should also apply a



very simple research tool: Ockham's razor. Sometimes called the principle of parsimony, Ockham's razor is a long-accepted aid to scientific logic that says the simplest answer is invariably best—that the more assumptions needed to explain a theory, the less likely that it's correct.

The strength of TIGHAR's case is the sheer amount of circumstantial evidence it can offer, all documented or supported by artifacts, none based on hearsay. The weakness, however, was amply if unintentionally voiced by Gillespie himself when he said, "If you conclude that something other than landing at Gardner happened to Amelia, you have to say everything we found was



Nikumaroro—once known as Gardner Island—remains as inhospitable as it was in the 1930s (left). Team members spent 10 days scavenging artifacts in 120-degree heat (above).

random. Coincidence. That you could go to any other Pacific island and come up with the same sort of stuff, and that flies in the face of reason."

Does it? A Western woman's shoe, a piece of airplane skin, a medicine bottle cap, a cigarette lighter, scraps of aircraft, several reports—including pilot John Lambrecht's—of "signs of recent habitation." The Gilbert Islands were liberally washed by the tides of war,

and even uninhabited ones such as Nikumaroro saw brief periods of colonization by native islanders, copra workers, and military personnel. Pieces of aircraft aluminum are trade items among the Gilbertese. The tides sprinkle beaches with baffling flotsam and jetsam. Shoes travel, and not only on Earhart's feet. Sailors and soldiers consume antacids.



Lambrecht's scouting flight and report on signs of recent habitation, a key piece of evidence, requires an awkward number of assumptions:

• That the thoroughly professional Lambrecht failed to spot Noonan and Earhart, who would have had nothing better to do than prepare to signal rescuers, perhaps with an oily fire or a display of bright-colored aircraft parts. (Maybe they were injured or already dead, or Lambrecht's overflight was too high, TIGHAR suggests.)

• That just days before the overflight the airplane had been dashed into such tiny fragments that it was no longer visible, even in shallow water, to a Navy pilot. (The waves can be enormous, TIGHAR says, and a severe storm to the north could have washed the airplane off the reef into the 2,000-foot abyss ringing the atoll.)

• And most troubling, that Lambrecht actually saw something suggestive of Earhart—a campfire, marks on the beach, any evidence left by a pair of urban Americans trying to survive on an atoll—yet was unable to convince the captain of the battleship *Colorado*, at one time only nine miles from Gardner, to put a launch ashore. (TIGHAR says Captain Wilhelm Friedell wanted to get back to Honolulu to unload the cadets, VIPs, and reporters who'd boarded the *Colorado* for the search. The captain may also have received a scouting report so thoroughly filtered through the chain of command that by the time it reached him it simply said that nothing relevant had been spotted.)

Ockham's razor requires a simpler answer: that Lambrecht flew over Gardner and saw the placard and flagpole—perhaps with a tattered Union Jack still flying—that the Royal Navy had erected only months earlier in a little sovereignty battle with the United States over bragging rights to the islet. Or perhaps he saw what he imagined was a native structure. In any case, he used the words "signs of recent habitation," not "anomalous signs of marooned aviators." Lambrecht used nearly identical phrasing to describe two other islands he searched, and in both cases he was describing native shacks or abandoned huts.

Another troubling question casts doubt upon a key TIGHAR thesis: that because radio signals were heard for three days after Earhart's disappearance, the Lockheed must have landed at low tide on the reef flat in good enough shape that its generator-equipped right engine could be run. Lockheed engi-

When the second expedition painstakingly excavated a grave rumored to be Earhart's, they discovered the bones of an infant (below). The shoe parts that TIGHAR claims are Earhart's were found nearby; the sheet of aluminum was unearthed on the western beach of the tiny atoll (left).



Found Objects

A partial list of what TIGHAR has brought back from Nikumaroro:

• A Japanese copy of a mid-1930s Ronson cigarette lighter. Such lighters were commonly sold in the States, and Fred Noonan was a smoker.

• An aluminum navigator's bookcase. Though made for a 1930s Consolidated PBY flying boat, screwholes show that it had been mounted in a nonstandard manner, suggesting it had been installed in a different kind of aircraft.

• A desiccated left shoe sole, Cat's Paw heel, and brass eyelet. The length of the sole, its stitch holes, and the size of the eyelet have been identified by the Biltrite Shoe Company as "consistent with" a woman's size-nine blucher-style oxford with a replacement heel. A photo of Earhart taken days before her disappearance show her in brass eyelet blucher oxfords with new heels.

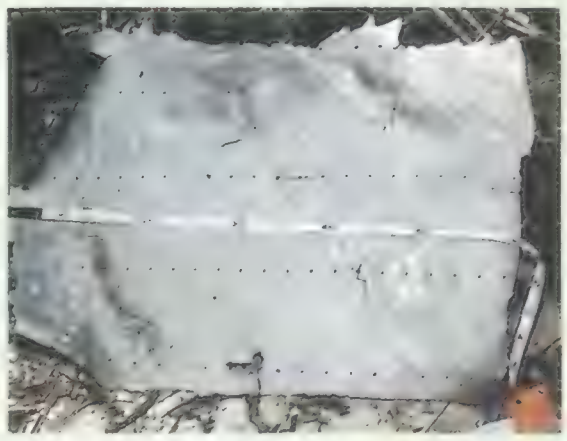


• A length of insulated aircraft radio antenna wire, found with the aircraft skin. The National Air and Space Museum's restoration workshops have analyzed the wire's construction and say it is identical to 1930s antenna wire and quite unlike that used during World War II.

• A panel resembling those used to secure aircraft interior trim. It bears the imprint of an eccentric crush-washer identical to those used elsewhere in Lockheed 10s to fasten interior flooring material and when found bore a minute scrap of bright blue fabric, obviously civilian rather than military.

• Part of a medical thermometer and a cap from a bottle of 1930s stomach medication. Earhart had been battling stomach upset during much of her final flight.

• A sheet of .032 Alclad aluminum alloy, one and a half by two feet, with several rows of rivet holes (below). According to a National Transportation Safety Board metallurgist, the sheet had been torn outward in a manner consistent with what would have resulted from waves thundering into a fuselage. The skin in many ways matches a belly panel of extant Lockheed 10s, except that the rivet holes are too close together, the rivet lines are too far apart, and there are no holes marking the location of a lateral stiffener.



neers in 1937 insisted that no such signals could be sent unless the airplane were on dry land and could recharge its batteries.

Yet between the time of the airplane's assumed reef landing and the reception of the last transmissions heard, the reef would have been subjected to seven high-tide cycles, and the Lockheed would have been sitting in over three feet of saltwater—high enough to reach nearly to the bottom of the engine nacelles and to begin lapping at the transmitter mounted on the cabin floor. For Earhart to have been able to restart an engine, much less make the airplane's electrical system work, we need to assume an absolutely placid tide change and a totally windless sea. And if she had left the airplane on the reef rather than taxiing it onto the beach, mightn't the reason have been flat tires or a collapsed landing gear, placing the fuselage even deeper in water?

The most critical assumption, however, is the sudden appearance of a storm so severe that its waves scattered an entire aircraft so thoroughly that not a single piece of aluminum was discernible by a Navy pilot and observer whose sole mission was to search for a silver twin-engine airplane. Perhaps such a storm did hit, for there was a tropical disturbance to the north on July 3, the waves from which would have reached Gardner just about when the last transmissions were heard. And perhaps John Lambrecht was simply a lousy search pilot.

There is no joy in questioning the efforts of 80 people—TIGHAR's expedition cadre, prime patrons, and Earhart enthusiasts—who have contributed enormous amounts of time and money to solve aviation's greatest mystery. But what many in TIGHAR consider an open-and-shut case in fact rests upon a number of debatable supports.

If the radio signals heard after Earhart's disappearance were spurious or misinterpreted, as the U.S. Coast Guard later maintained...if John Lambrecht never intended to imply that he'd seen signs of Earhart on Gardner...if the "Lockheed belly skin" is actually from an Air Corps fighter or a Navy cargo plane...if signs of an "overnight bivouac" seen by a British colonial officer who visited the island three months after Earhart's disappearance were misinterpreted or created by rovers from another island...then perhaps the truth is that Earhart flew—or Noonan plotted—the line of position inaccurately and missed Gardner entirely.

Searchers had to cut crude paths through dense vegetation inhabited by insects, rats, and huge crabs.



Biologist Thomas Huxley once wrote, "The great tragedy of science [is] the slaying of a beautiful hypothesis by an ugly fact." It will take at least one more expedition to Nikumaroro before we know the facts—beautiful or ugly—for certain.

by Frank Kuznik

Photographs by Lee Battaglia

It's the story that won't die. A legion of UFO buffs is convinced that Wright-Patterson Air Force Base is hiding...

Aliens in the Basement

The official fact sheet on Project Blue Book, the Air Force program that investigated 12,000-plus unidentified flying object sightings from 1947 to 1969, reads like your standard military briefing paper—until the very end. Then it drops this incredible disclaimer: "There are not now, nor have there ever been, any extraterrestrial visitors or equipment on Wright-Patterson Air Force Base."

Little alien corpses kept frozen and hidden away on an Ohio military base may sound like sci-fi lunacy to the uninitiated. But for 45 years, this is one UFO story that's refused to go away. And for that the military has mostly itself to blame. It was, after all, Roswell Army Air Field in New Mexico that started the whole business in the summer of 1947 by announcing that it had recovered a crashed "flying disc."

Never mind that they were quick to say, *No, wait, make that a weather balloon*. Over the last decade in particular, a small army of authors, researchers, and TV hucksters has done a highly imaginative job of filling in the details of the "Roswell Incident," as it's come to be known. Unlike most UFO yarns, their stories are based on enough interviews, photographs, and other evidence to seem...well, not impossible.

Ultimately all the stories lead to Wright-Patterson, the headquarters of Project Blue Book and the site where the wreckage of the spaceship and the bodies of its crew were allegedly taken for analysis. Then they come to an abrupt halt. "We know the material was taken to Wright-Pat," Mark Rodeghier of the J. Allen Hynek Center for UFO Studies says. "But that's where the trail grows very cold; we don't have any sources there."

That's enough to get the gears of any red-blooded space writer racing. What if I could spend some time poking around the labs at Wright-Patterson? There's no telling what I might find. Admittedly, the odds of actually coming back with the goods are slim. But as longtime UFO investigator Don Berliner points out, "It's potentially the biggest story ever."

My first contact with the base public relations staff makes me think I might be on to something. "The little green men story? I get three calls a week about it," says Major Aurelia Blake. She assures me there's no crashed saucer or alien corpses under wraps, but says I'm welcome to tour the base. A few hours later, however, she calls back. "Why don't you think about doing something else?" she asks. "We've got some great wind tunnels here."

The Roswell Incident dovetails with the birth of the modern era of flying saucers, so named in June 1947 when a private pilot reported seeing nine disc-shaped objects flying over Washington's Mt. Rainier "like saucers skipping on water." That sighting triggered a nationwide wave of UFO reports that made headlines for months afterwards.

Far and away the wildest headlines came out of Roswell, where two weeks after the Mt. Rainier sighting a sheep farmer named Mac Brazel clumped into the sheriff's office to report something he couldn't identify cluttering one of his fields—something, he said, that had fallen out of the sky and broken into shiny pieces.

Brazel's ranch lay some 75 miles northwest of Roswell near a tiny town called Corona, in a stretch of scrub desert neatly triangulated by what were then arguably the three most security-sensitive military installations in the world: the Roswell Army Air Field, home of the 509th Bomb Group, the world's only atomic bomb squadron; Los Alamos, where the bomb had been developed and was still being refined; and the White Sands Missile Range. Not surprisingly, Sheriff George Wilcox suggested that Brazel report his find to authorities at the nearby Roswell base.

After sending two officers out to reconnoiter the crash site and retrieve some samples, the 509th brass went ballistic, mounting a full-scale recovery effort and firing off its "flying disc" press release. On Tuesday, July 8, newspapers across the country carried headlines announcing that Roswell Army


18F

Air Field had captured a flying saucer.

The next day, though, many carried a follow-up story explaining that the wreckage wasn't a flying saucer after all. After being flown to Fort Worth Army Air Field, it was identified as the remains of a weather balloon. An Associated Press wire story that ran in a number of papers on July 9 described the wreckage as "consisting of large numbers of pieces of paper covered with a foil-like substance, and pieced together with small sticks, much like a kite. Scattered with the materials over an area about 200 yards across were pieces of gray rubber."

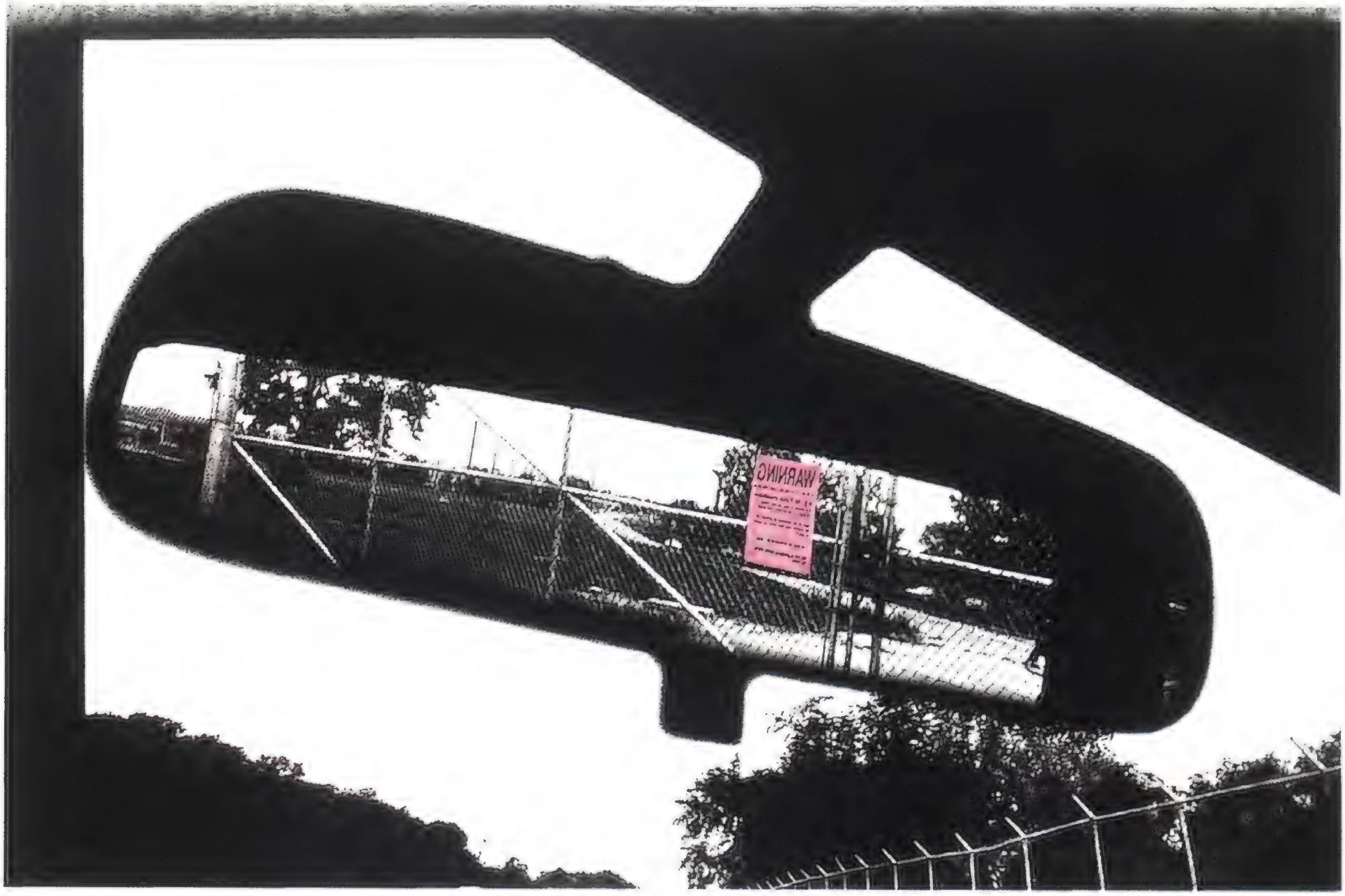
Before my trip to Wright-Patterson, I tracked down Walter Haut, the retired base public information officer who wrote the infamous press release, and asked him if he ever actually saw the wreckage. "No, and I feel like an idiot every time somebody asks me that," he said ruefully. "I got a call from the base commander, who basically dictated what was in the press release."

And how did he feel when the bottom dropped out of the story? "I probably wiped the perspiration from my brow and said *Thank goodness, we're off the hook now,*" he said. "Very frankly, I don't think I believed that we had something from outer space. I think most of us felt we were being hoodwinked somewhere down the pike."

This is not, incidentally, what Haut believes today. "I feel there was a crash of an extraterrestrial vehicle near Corona," he says firmly. What happened in the intervening 45 years to change his mind?

For a long time, not much. Nobody questioned the military in 1947, so when the captured disc metamorphosed into a weather balloon, the explanation was accepted and the story largely forgotten. It was a revival of the Roswell story in the '70s that convinced Haut and thousands of others that the Air Force really hadn't been on the up and up. It began inauspiciously in the person of Stanton Friedman, a nuclear physicist and well-traveled UFO lecturer. At his talks, Friedman would occasionally meet people who had been in New Mexico in 1947. Bit by bit, their stories began to form a picture startlingly different from the official version's. Friedman dug further with the help of a friend, William Moore, who in turn enlisted writer Charles Berlitz of Bermuda Triangle fame to turn their findings into a book published in 1980 called *The Roswell Incident.*

The book blows off the weather balloon explanation as a hastily concocted cover story and argues that the Air Force really did recover a crashed saucer, as well as several alien bodies. The wreckage and bodies were taken to Wright-Patterson for analysis, it said, and everyone involved in collecting, transporting, and studying them became part of a massive conspiracy of silence. There's a lot of chaff in *The Roswell Incident,* including some blatant hokum about Gemini and Apollo astronauts spotting flying saucers. But



the main idea—that the government was sitting on a captured saucer—fell on some fertile ground. Other books followed, including last year's *UFO Crash at Roswell.* Television found the story irresistible. The series "In Search Of' did an episode on it. A trashy 1988 production called "UFO Coverup? Live" featured two mysterious "intelligence sources" who revealed that the captured aliens like Tibetan music and strawberry ice cream. And in September 1989, "Unsolved Mysteries" featured the story on its season premiere, attracting an impressive 28 million viewers.

The captured saucer idea even took root overseas. "I was visiting Kapustin Yar, a Soviet missile base, two years ago when the head of the base asked me if we had any UFOs," recalls Gregg Herken, chairman of the National Air and Space Museum's department of space history. "I thought he was kidding at first, but he turned out to be quite serious."


Roswell Daily Record

RECORD PHONES
Business Office 2288
News Department 2287

Leased Wire Associated Press

RAAF Captures Flying Saucer On Ranch in Roswell Region

Claims Army Is Stacking Courts Martial

Indiana Senator Lays Protest Before Patterson

House Passes Tax Slash by Large Margin

Defeat Amendment By Dames to Remove Many from Rolls

Security Council Paves Way to Talks On Arms Reductions

No Details of Flying Disk Are Revealed

Roswell Hardware Man and Wife Report Disk Seen

Movies as Usual

GRAND

Some of Soviet Satellites May Attend Paris Meeting

Miners and Operato

It's a good thing the Soviet commander never saw the UFO exhibit in the world-famous United States Air Force Museum adjacent to Wright-Patterson, which the PR staff had encouraged me to check out before coming to the base. It turns out to be a single glass case filled with fake photos and hoax items that wouldn't cut it on the old Flash Gordon serials. A blob of melted plastic, a big hunk of cinder, a crumpled metal ball stuffed with radio tubes, springs, and speedometer cable—this is it? An Air Force museum so comprehensive it has a wall covered with the history of *spark plugs,* and there's nothing to show for 23 years of UFO investigations but a pile of rusty junk? Very odd.

On to the base itself, a vast tract bigger than half of Dayton's suburbs. An alien rescue team could search the place for six months and not find their friends. But I know where to look. One place is the infamous Hangar 18, where the bodies were allegedly stored in deep freeze. Another is Wright Laboratory, one of four Air Force "superlabs," where nearly $1 billion is spent annually on research in propulsion and power, avionics, materials, electronics, and the like. If they learned anything from the saucer, there should be signs of it in the labs. I also want to see the Foreign Aerospace Science and Technology Center, the secret facility where the Air Force takes apart foreign aircraft to see what makes them tick.

The first thing I learn is that there is no Hangar 18. There's a *Building* 18 complex that at one time housed "cold cells," rooms that could be cooled to sub-zero temperatures to test engines under Arctic conditions. In 18A I meet Fred Oliver, a folksy division chief and engineer who's become the base spokesman on the subject of aliens. He commiserates with me in my disappointment at finding generic government offices. "I know," he says, "you picture walking into a building with a big curved top where you go through all these guards, and run your card through a cipher lock, then there's this spaceship going *rrrrr, rrrrr* that gives off a green glow."

Exactly. How does he know that scene in such detail? Before I can ask, he's deep into a Viewgraph briefing. You can't meet anybody at Wright-Patterson without getting a Viewgraph briefing; it's as automatic as a handshake. It's also a lot like the lessons you used to get in high school on overhead projectors, except that instead of scrawled equations or French verb conjugations you get to look at big bright slides of organization charts and turbine engines. Finally Oliver works his way to the bottom of a six-inch stack of slides and asks, "Any questions?"

"Where are the bodies?"

"There are no bodies," he says kindly, like a dad breaking the bad news about the tooth fairy. But if a saucer did crash-land, wouldn't the remains be at Wright-Patterson? "That's a sensible conclusion," he admits. "Since the beginning of time, this has been the nation's center of aerospace R&D."

I suggest that a good strategy for hiding aliens might be to act like you've got nothing to hide, bring reporters on base, then overwhelm them with Viewgraphs. "And walk them till they drop," Oliver agrees. "I'm going to get in trouble for saying this, but give us some credit—wouldn't you think we'd be smart enough to hide the bodies if they were here? Do you really think you'd get to see them?"

In any case, after a tour of the Building 18 complex, it's clear I'm not going to see them there. The cold cells are long gone, gutted and replaced with recon-camera maintenance and repair shops and testing equipment. The basement of 18A has a huge facility that can pump pressure- and temperature-controlled air to a number of "environmental chambers," but there's nothing resembling a 24-hour cryogenic operation. If the bodies were here, they're gone now.

My next interview is with Keith Richey, chief scientist of Wright Laboratory. The determined set of his face tells me he obviously has better things to do with his time than talk about aliens. "Do you have the Air Force fact sheet on Project Blue Book?" he asks as soon as I broach the subject. "My own personal knowledge corroborates that. So that's where we are on that subject."

Richey has fascinating tales to tell of running a superlab and developing the kind of weaponry we saw in Desert Storm and how we'll be able to launch the next generation of smart bombs from hundreds of miles away instead of just a few and still park them up somebody's keister. Eventually I steer the conversation back to aerodynamics and ask how efficient a saucer shape would be for flying.

"Well, it's not very efficient," Richey says. "What you want is a multiplica-

tion factor of 20 times the lift for the amount of drag you generate, and it doesn't generate much lift."

I try a different tack. What if something dropped out of the sky tomorrow and was brought to Wright Laboratory for analysis? Could Richey and his 2,000 scientists and engineers figure out what makes it go?

"We could do it," he says, pride getting the best of his no-nonsense demeanor. "We could take it apart, analyze it, and I don't know how long it would take, but with enough effort we could find out what it would do." So presumably if a saucer had shown up at the base in '47...? Richey doesn't hesitate. "You would have seen it flying. You would probably be buying tickets for it by now."

Before I can weigh the implications of that remark, I'm hustled off to the Flight Dynamics lab for a Viewgraph briefing by Colonel Dick Borowski. A congenial fighter pilot who saw action in Vietnam, Borowski smiles and says, "I know you came looking for little green men," then unleashes a dazzling overview of the new technologies his division is developing. Acoustics testing. Thermoplastics. Forebody vortex flow control. Flight simulation. By the time he's done, I'm too dazed to ask him where he's hiding the bodies.

My pulse quickens as I'm led down a maze of hallways and through a heavily locked door by Richard Moss, chief of cockpit development. No bodies in the inner sanctum, though—just a series of rooms with liquid crystal display screens in various test stages. The first one shows a simplistic terrain with targets in the air and on the ground, all irritatingly out of focus. "Here, put these on," a technician says, handing me a pair of Captain Video sunglasses with tiny on/off buttons on the frames.

"Are these a souvenir?" I ask her.

She laughs. "Those cost $2,000."

I look at the screen, where suddenly everything is not only in focus but in 3D. There's a truck in the forefront, then some mountains, then—wait a minute! A saucer-shaped object is hovering in the sky.

"That's a flying saucer," I tell the tech excitedly.

She squints at the screen. "The red thing? I don't know what that is." She looks at Moss.

"That's a transport aircraft," he says.

There's more rooms and more screens, but I'm too preoccupied to pay attention. When Moss finally escorts me from the building, he gives me a meaningful look and says, "You've only seen the tip of the iceberg."

I start my second day at Wright-Patterson in the museum research library, hoping to find original Roswell documents that will cut through some of the hype. When I tell the librarian what I'm looking for, he gets a pained look and barks, "Every time they run that damned Roswell thing in the tabloids all the crazies come out. The old man [museum director Richard Uppstrom] says he wishes we had one of the bodies to put downstairs and charge a dollar a pop to see. We'd never have to ask Congress for money again."



Army Finds Air Saucer On Ranch in New Mexico

Disk Goes To High Officers

Picked Up Last Week

ROSWELL, N. M.—(AP)—The Army Air Force here today announced a flying disk has been found on a ranch near Roswell and is in Army possession.

'Flying disc' turns up as just hot air

Fort Worth, Tex., July 9 (AP).—An examination by the Army revealed last night a mysterious object found on a lonely New Mexico ranch was a harmless high-altitude weather balloon — not a grounded flying disc.

Disappointingly, the museum's UFO files are in the same league as its UFO exhibit. There's a ton of Blue Book summary reports, along with University of Colorado and National Academy of Sciences studies agreeing with the Air Force's conclusion that UFOs don't merit serious attention. There's a detailed aerodynamic analysis of virtually every shape UFOs have ever taken, pronouncing them all "impracticable." And in year after year of briefing papers, there are remarks like this one: "It is unlikely that positive proof of [flying saucers'] existence will be obtained without examination of the remains of crashed objects."

Exactly.

This afternoon's lab run is through the materials directorate, where after the obligatory Snoozegraph briefing I'm handed off to Lieutenant Colonel James Hansen. He's got a basement full of wild machinery that tests composite metals and ceramics for the National Aerospace Plane, the hypersonic hybrid that will fly into space.

No bodies here either. But watching strips of exotic metals being tortured under incredible heat and pressure, I realize I may be a lot closer to pieces of a crashed saucer than I think. I ask Hansen the same question I asked Richey yesterday about analyzing something that dropped out of the sky—only this time in the past tense.

"If somebody had brought in composite material 20 years ago, we wouldn't have had any idea what it was," he admits. "Now, we could take it apart down to its atoms."

Suddenly it all begins to add up—the glowing spaceship scene Oliver described, Richey's cryptic boast about selling tickets, the saucer on the screen, and now Hansen's admission that we've only recently been able to figure out composites. It's taken nearly 40 years to crack the secrets of the Roswell wreckage.

And today we're developing a freak craft that can take off from a runway and fly into space—just like flying saucers do.

Coincidence? Think about it.

My last shot at finding the bodies is the super-secret Foreign Technology center. It took negotiations on the order of a Middle East peace conference to get an appointment there, and I'm pleased to see that the public information officer waiting for me is a novice filling in for someone who just quit. No telling where she might take me.



We drive around the building first. It's a nondescript red and gray affair, like a warehouse in a suburban industrial park, only a lot bigger. My guide confides that you need top-secret clearance to get almost anywhere inside. "It's basically a huge safe," she says.

We park at the front entrance, greet an officer on the way out, and step into what might be the lobby of Krupp's Widget Works—except for the heavy-duty security desk with the big control panel. I look at my guide and make an expectant move toward the desk. She doesn't budge.

"That's it," she says.

"That's it?"

"That's all you can see."

And that's that.

No flying saucer story would be complete without an anonymous highly placed military source who spills A Big Secret. Mine didn't materialize until I got back to Washington, where I brooded for days over what I had seen—or hadn't seen, actually.

Studying a map of New Mexico got me thinking about all the secret flying and testing that was done at Roswell and Los Alamos and White Sands after the war. If there was ever a place where something the military wanted kept under wraps was likely to fall from the sky, it was central New Mexico in 1947. That thought prompted me to call my source—a retired Air Force officer I met while touring Wright-Patterson who is, alas, still in a position too sensitive to allow his name to be used. He was way ahead of me.

"All these years I've been hearing about this Roswell incident," he said, "and knowing Air Force history like I do, and how hush-hush the 509th was, I just set it in my mind that they must have crashed one with a nuke that came close to going off, or maybe [exploded but with] a low-level yield that we don't know about. I could never prove anything one way or another. But with the 509th that close, and—well, B-29s weren't noted for *not* crashing, let's put it that way."

It's a nifty theory, but just a theory. Like all good stories, Roswell expands to accommodate whatever you bring to it. That's the nature of myths and legends—they're detailed enough to seem real, yet fuzzy enough to stay always just beyond the reach of objective proof.

In that sense, it was better that I didn't find any bodies. Naturally I'm disappointed at not having broken the biggest story of all time. But I've done my part for the legend. Substantive or not, Roswell grows a little with each retelling. And this one lets you have it both ways. If you prefer a purely rational, scientific world, you can take comfort in the fact that my mission was—just as you knew it would be—doomed to failure.

If you prefer a world filled with mystery and intrigue, well, I haven't disturbed that either. The Air Force is still covering up a big-time screw-up...or just now cracking the secret of interstellar propulsion...or sitting on the biggest cosmic kick in the pants since the Big Bang.

Whatever.


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The El Centro Blues

Presenting the hardest working men in show business.



by George C. Larson

Photographs by Chad Slattery

When the Blue Angels perform over Moscow sometime this September, it will be a display—both figuratively and literally—of just how much the world has changed. The thought of blue and gold Navy F/A-18s doing the dirty loop, the diamond 360, and other maneuvers over the capital of our former adversary seems incredible, but the Blues' itinerary looked firm earlier this summer. All bets are that next year's official Blue Angels publicity still will feature the Kremlin in the background.

Whatever the outcome, the European tour suggests a subtle shift in the way the Navy's premier image builders are employed. Since the Blue Angels were created in 1946 by order of Admiral Chester Nimitz, the squadron has always played a promotional role of some kind. Nimitz simply wanted to keep naval air power in the public eye, but during the Cold War years the Blues' primary mission was recruiting: to stir something within young people that made them want to run out and join the United States Navy. But young Europeans are clearly no targets for the Navy Recruiting Command, and this summer's trip is as wired to the Department of State as it is to the Navy.

The blue and gold aircraft of the U.S. Navy's flight demonstration team have been thrilling airshow crowds with precision flying since the end of World War II. From his slot position in the formation, Pat Rainey (above) rides herd on the rest of the team.

By the time they arrive in Moscow the team will be nearing the end of its season, and each maneuver will have been honed to perfection. It does not come naturally to human beings to fly four airplanes through a formation roll while they are 36 inches apart, and before the Blue Angels are ready for an airshow season, they have to learn to do what they do by practicing it over and over again. Like you and I, they have days when things don't go well, when they don't fly perfectly, when any member of the team can go through some soul-searching. For this period of trial and tribulation, they go to a place in the middle of the California desert called the El Centro Naval Air Facility.

For 25 years, right after the winter holiday season, the entire Blue Angels squadron—about 120 people—have departed their headquarters in Pensacola, Florida, left their families behind, and moved to California's Imperial Valley. The airfield lies just west of the town of El Centro, "where the sun spends the winter," according to signs at the city line. Now that the little agricultural community is bisected by Interstate 8, which runs east and west as straight as a taut rope, it has acquired the fast-food franchises and motels that line all such highways. Big-

time fun is available many miles to the west in San Diego, but El Centro has little to distract the team members—discovering a new barbecue joint is a big deal—and the Blue Angels seem to like it that way.

The clear winter skies of the Imperial Valley make the area around El Centro ideal for flying. The airfield is surrounded by farms growing alfalfa and hay for cattle feed. About 200 yards from the airfield's south entrance, where an old Grumman F11F fighter mounted on a pylon pulls station guard duty, the Blue Angels set up headquarters in a one-story flat-roof building. The place calls to mind an American Legion hall in a small town.

In front of headquarters, each parking space is marked with a neatly stenciled sign bearing a pilot's number. Within the Blue Angels organization,

1992 Blue Angels Officers

Demonstration Pilots:

#1 Cmdr. Greg Wooldridge, USN, CO and Flight Leader ("Boss")

#2 Lt. Larry Packer, USN, Right Wing ("Fudge")

#3 Lt. Doug Thompson, USN, Left Wing ("Dino")

#4 Lt. Cmdr. Pat Rainey, USN, Slot ("Irish")

#5 Lt. John Foley, USN, Lead Solo ("Gucci")

#6 Capt. Ken Switzer, USMC, Opposing Solo ("Thumper")

#7 Lt. Dave Stewart, USN, Narrator ("Hoops")

#8 Lt. Cmdr. Randy Duhrkopf, USN, Events Coordinator ("Durk")

C-130 Pilots:

M1 Capt. Scott Larsen, USMC

M2 Capt. John Skinner, USMC

M3 Capt. Joe Michalak, USMC

Support Officers:

Lt. Kevin Fischer, USN, Maintenance Officer

Lt. Cmdr. Pat Spruce, USN, Flight Surgeon

Lt. John Ottery, USN, Administrative Officer

Lt. Cmdr. Chuck Franklin, USN, Public Affairs Officer

Lt. Dismas Meehan, USN, Supply Officer







Precision teamwork is also important on the ground: the pilots spend hours practicing their marching to and from the jets (left). Reviewing the videotape of a hop is a regular part of a practice's debriefing (above).

each pilot is a number: 1 through 4 designate positions within the four-plane diamond that flies close-formation maneuvers to demonstrate teamwork; 5 and 6 are the two solo aircraft that often mimic aerial combat and later join up with the diamond during part of the performance to produce a triangular formation called the delta; 7 is the narrator and 8 is the events coordinator. Depending on the turnover of the team, the pilots rotate positions in the formation each year in order to get needed experience or provide overlapping tours so that one pilot can teach another. Each pilot serves two years, except the narrator, who gets an extra year to compensate for his time behind the microphone. Then, with little fanfare, they all return to fleet duty and to airplanes painted gray.

While in flight and during briefings, the pilots use only their nicknames. But when they speak in organizational terms, they refer to the numbers. There's only one exception: number 1, the squadron commander and flight leader, is referred to simply as the Boss.

"Admin." The Boss, currently Commander Greg Wooldridge, doesn't say the word very loud, yet it acts like a switch. The big monitor in the briefing room had been tuned to a music video cable channel, but now, at the word that signals the start of every briefing for the Blue Angel pilots, everything shuts down abruptly.

"Yessir, Boss. I'm real happy to be here this morning, and I'm looking forward to today's hop," says number 4, Lieutenant Commander Pat ("Irish") Rainey, the slot pilot who flies between the two wing positions and directly aft of the lead. He advises that today the diamond will be lowering its minimum altitude as part of an incremental march downward from 2,000 feet at the beginning of winter practice to 250 feet by the time the season arrives. Rainey points out that "some of the jets are kinda screwy...the 5 jet has problems," but they're in rework and one is due for a new engine. "If maintenance is as awesome as usual, we might get 'em in time," he says. "That's it."

Happy to be here? Looking forward to today's hop? It sounds as strange to the uninitiated as an unfamiliar religious service. "For 15 years it's been done like this," Rainey says later about the rituals that prevail among the Blue Angels. The order of business and even some of the words are written down in a manual. And even if it's not written down, the briefing will officially end when the Boss says, "Diamond, have a good one." Phrases like "happy to be here" have a humbling quality, according to Rainey. "All your friends are out on ships," he says. "This reminds us how lucky we are to have this job."

Groups invent rituals for a reason, and in this case the rituals are undeniably reassuring. Military demonstration teams face serious risks: they fly at low altitudes, at high speeds, and in extremely tight formations. The Blue Angels have not lost a team member to an accident since July 1985, when an A-4 pilot died in a midair collision during a maneuver called the blivet. The Blue Angels no longer perform the blivet, and they no longer fly the A-4. The most recent mishap occurred during winter training in 1990, when the Boss and the number 2 jet collided. Both pilots survived.

Now the ritualistic language has become as much a part of the briefing as the weather report, which today calls for scattered clouds at 20,000 feet. This forecast has become something of a team joke: there hasn't been a cloud within 200 miles for a couple of weeks. After the weather briefing, number 3, Lieutenant Doug Thompson, flying left wing under the *nom de vol* "Dino," provides some safety points.

They review the scheduled times for the morning hop ("walk at zero seven forty-five no kidding"), local flying conditions and competing traffic (the airfield will be closed for their 45-minute hop), the takeoff runway, the runway to land on if someone needs arresting gear, where to eject (away from people and property) and where to divert (Yuma).

Then a strange thing happens. As if someone had said "Let us pray," the team members all bow their heads; some close their eyes. Then the Boss



To perfect maneuvers such as the fortus (right), the Blue Angels fly twice a day during training. By year's end, Blue Angel narrator Dave Stewart (below) will have addressed perhaps as many as 10 million people, but it all starts with an audience of desert scrub.

Solo maneuvers, such as the tuck-away cross (left), demonstrate the maximum performance capabilities of the F/A-18 Hornet.

begins to recite his radio calls in a soft, low voice, almost a whisper. As he goes through the calls, they all mentally fly the hop.

"Let's run 'em up...burn-errrs *on*...up-ah-we-go-oo...a lit-tle more pull...stand-by the boards, *boards*."

The Boss murmurs them through





the hop: the diamond 360, the double farvel, the dirty loop, the tuck-under break—some recently devised maneuvers but mostly traditional stuff the diamond has done for so many years that their origins have been lost. And so it goes until:

"Ease in the brakes...ease in the brakes...brakes." They're parked.

The "Zen" flying, as the ritual is called, is over, and now they'll go out and do it for real. But first each pilot proclaims his personal goal for the hop. The Boss wants to work on his head-ons—maneuvers that aim toward the crowd; he's been having trouble lining up. Number 2, Lieutenant Larry ("Fudge") Packer, picks on his echelon work—"I feel I made no progress yesterday"—and Thompson wants to focus on his position just prior to the tuck-under break. Rainey wants his double farvel to get better: he over-yugged it yesterday.

"Diamond, let's have a good one."



A welcome mat greets the squadron when the Blues migrate to the El Centro Naval Air Facility each winter.

While the four-plane diamond flies smooth, aerobatic maneuvers, the two solo pilots practice a brand of violent, high-performance, on-the-edge flying. Lieutenant John Foley, number 5, the lead solo who answers to "Gucci" (sometimes abbreviated to "Gooch"), and number 6, Captain Ken ("Thumper") Switzer, the sole Marine among the Blue Angel pilots, operate independently from the diamond throughout most of the winter, and they have their own separate briefings. Although they perform some of the same rituals as the diamond pilots, they are less formal and their briefings often end with a high five. Toward the end of the practice period for the delta formation work, the solos and diamonds will fly and brief together.

Gucci and Thumper—fancy luggage and a Disney bunny. Their nicknames are a comic juxtaposition, but Foley and Switzer actually sound alike when they talk. "What you absolutely have to have is complete trust, obviously, in everything we do, but also he needs to know what I'm thinking," says Foley, whose words tumble out with the locker room gusto of a former Navy football player. "We need to become almost like brothers. In fact, it is that close. We do everything together. Our standard day is we get up at about 5:45, we go running three miles together, we drive in the car together—he always drives, I get to ride—and we eat together, we brief together, we go to the gym together, we work out every night together, basically really become close.

"And you can feel it in the air. He knows what I'm thinking. We're up there on the radios and we're talking, and he can tell when there's something bothering me. He can tell when I'm not liking the weather, I'm not liking the situation. And he knows through my voice inflections what I need out of him, whether I need a change or something like that.

"We need to have that because our stuff is so close. Not closer than the diamond—they fly actually closer—but the actual speed. You can get yourself into a predicament relatively quickly if you're not careful."

Flying in the diamond requires gradual and precise stick movements, but the solos' brand of flying is less restrained. "We slap that stick around," says Foley. Full stick deflection—"bangin' off the stops"—and wide throttle excursions from idle to full blower are typical. Foley recalls that when he first came on board and got a ride in the back seat, "I could not be*lieve* the airplane held together."

This type of flying involves some serious Gs—sometimes seven and a half times the pull of gravity. But none of the pilots wear G-suits to compensate for forces that can drain blood from the brain. Reasons range from "It takes too much time to put 'em on after the walk down" to "We just don't need 'em." As part of the bargain for being excused by the Navy from wearing the G-suits, every Blue Angels pilot—most are in their mid-30s—works out daily at a health club in El Centro.

Another key difference between diamond and solo flying is that the solos fly to a clock and adjust their timing to the diamond. When the solo pilots first arrive at a show site, they will circle overhead to locate their visual references, which they recognize from studying eight-by-ten aerial photographs during the week prior to a show. Their timing will depend on spotting these landmarks at a target airspeed of 400 knots (460 mph).

A solo maneuver begins as both airplanes fly circular patterns away from each other at about 5,000 feet above and three miles from a designated center point. Foley and Switzer both have clocks mounted on their glare shields.



The Hornet

Since 1986 the Blues have been flying the McDonnell Douglas F/A-18 Hornet. The single-seat, twin-engine, multi-mission aircraft has two General Electric F404-GE-400 turbofan engines that provide a total of 32,000 pounds of thrust and Mach 1.7-plus speed.



When Switzer sees his roll-in point off his wing, he calls "Abeam," and on Foley's call, "Stand by...*mark it*," each pilot resets his clock and begins to roll in for the run toward the other.

Both pilots will try to cross a three-mile reference point at precisely the same clock time. If Switzer crosses early, late, or off his target airspeed, he calls the error over the radio, and it's up to Foley to adjust. Every four and a half seconds they narrow the distance between them by one mile. If Switzer doesn't see Foley by the time they're a mile apart, he aborts. If he sees him, he has only moments to adjust his flight path to set the "crowd"—the distance that will separate them when they cross. Switzer also "cheats" to adjust for the angle from the audience so that both airplanes will appear to overlap perfectly. When they cross at center line and everything works, "it looks like he goes right through me," says Foley.

After every practice hop, the pilots debrief. For the solos, debriefing is like the simple conversation between two athletes. But the diamond debriefing is more elaborate. Today the Boss is unhappy about a couple of things, especially the "walk down," the drill team procession to the airplanes. "We're not the best marchin' group in the world," he says, wincing.

During the video replay, Rainey's role as slot pilot becomes plain as his ad hoc calls are heard—"Let's ease it out" and "A little pull." His calls are distinctive, higher in pitch than the Boss' baritone whispering. The slot pilot has an overview of the entire diamond and today Rainey's concerned about a problem with coordinating the aircrafts' smoke systems so that the smoke comes on at exactly the same moment.

They confess their sins and list their "safeties"—deviations from safety rules—as they go around the table. "I was disappointed in myself on the placement," says the Boss. "I know I had a safety; I was low out of the dirty loop, 250 [feet], looking for 300 feet.... I'll fix it, make it better."

Packer is next. He admits he "got out ahead of the Boss" and "missed a call on the fleur-de-lis."

"I think I know what happened on the tuck-under break," says Thompson.



Sometimes even "Fat Albert," the C-130 that transports squadron equipment between shows, gets to perform its jet-assisted takeoff (JATO) for a crowd (above). In order to withstand the 7.5 G-forces they encounter during maneuvers, John Foley and Ken Switzer lift weights.



He also says that he "overpulled" on the barrel-roll break and took too long to rejoin after a maneuver that split the formation.

Rainey "enjoyed the hop" and thought it was "going great guns until a mismatch on the burners in the dirty loop."



The Blue Angels have never missed a show due to maintenance problems, thanks to some 100 enlisted Navy and Marine Corps personnel who care for the squadron's aircraft (above).

He becomes animated, his face reddening slightly. He strides to the blackboard and sketches where maneuvers are going sour. In what amounts to a chewing out, he points out that one rendezvous—when the group rejoins after a maneuver that splits it up—is not improving. He is worried that they aren't ready to have the solos join them for the delta formation work, which needs to begin in only a few days. The start



of the season is staring them in the face. "We need to get 'em in," he implores.

With impeccable timing, the Boss suggests a "burrito break." Earlier that morning, Glen Huber, one of many "honorary" Blue Angels, perennial friends of the squadron throughout the United States, delivered a stack of cartons crammed with homemade burritos. The pilots tear into them like grizzlies at a campsite.

Paper wrappers and plastic sauce containers are scattered across the conference table when the team returns to the video replay. The debriefings also include critiques by the squadron flight surgeon, Lieutenant Pat ("Doc") Spruce. His job is to observe the team's performance from the ground, the only perspective from which critical alignments and angles can be seen. During each practice hop he stands 1,500 yards from center point, which is represented by a pair of semi-trailers parked at the center of the five-mile-radius maneuvering circle. He grades each maneuver for alignment on center point, timing of crossing maneuvers, and precision of formation, among other criteria. "Critiquing gives me a sense of how things are going," Spruce says, alluding to his responsibility to monitor morale and the effects of stress.

When they finally finish, the Boss says, "All right, good practice. Let's do it again." You get the feeling he has said it exactly that way hundreds of times before.

That night, after their workout, the pilots and staff officers head for a fa-

Squadron commander, flight leader, and "the Boss," Greg Wooldridge (left) has accumulated more than 6,600 mishap-free hours in the air and 650 carrier landings. The day starts early for the Blue Angels: by 5:30 a.m. the maintenance troops are fueling and inspecting the jets (below).



How to Talk Like an Angel

A selected glossary of Blue Angels terminology:

blower afterburner, also burner
boards speed brakes, large surfaces extended hydraulically from the F/A-18 to slow it down by creating drag
burner afterburner, also blower
canopy transparent plastic enclosure covering the cockpit
center point the center of a five-mile maneuvering circle within which the team flies; serves as a reference
cheat alter the altitude of an airplane so that a formation's alignment looks correct to the audience
crowd the distance between aircraft in certain maneuvers; also the audience
dirty gear, flaps, tail hook extended
hop short flight
jet one's airplane; never "my Hornet" or "my F/A-18" but "my jet"
no kidding absolutely, as in "a no kidding five-mile radius"
on board to join; also, to incorporate into one's thinking without hesitation
overpulled excessive back pressure on the control stick
safety any deviation from a safe-flight rule
station guard an airplane placed upon a pylon in a prominent place on any military air base
stops mechanical limits on an aircraft's control surfaces
yug an abrupt control movement immediately followed by a cancelling movement in order to unload the wings of a jet and produce a momentary condition of ballistic, or zero-g flight; usually used just prior to a maneuver for effect
Zen a mental picture that is the focus of a Blue Angel pilot's concentration

vorite restaurant well outside of town. There are trays of Mexican food and pitchers of beer, and some friends of the team, including a professional drag racer and an L.A. cop, join them. The food and conversation help them put the day behind them. As the Boss had promised, tomorrow they will "do it again."

The following day, the Blue Angels' narrator, number 7, Lieutenant Dave ("Hoops") Stewart, stands in the desert rehearsing his script for an audience of mesquite and cactus: "The Blue Angels diamond will momentarily be making its approach from the right..." Above him both the diamond and the solos look better. Over the radio Thompson is jubilant. "I really feel like today I got the left [throttle] hand workin' for the first time," he calls. From his slot position Rainey offers an instant critique: "A thousand percent better, guys."

It's been over a month since the Blues arrived in El Centro and started practicing for the 1992 season, which is now less than two weeks away. In the next nine months they will fly 60 airshows around the country. Despite the long separations from their families and the risks of this kind of flying, Navy pilots have always yearned to have their tickets punched with a Blue Angels tour. All must go through an application procedure akin to joining a college fraternity—they call it "rushing the team"—and there is a surprising emphasis on socializing to give current team members a chance to size up the applicants.

"Irish and I applied together, and we'd call each other," Spruce says. "He went down one weekend, and I asked him, 'How'd it go?' And he said, 'I don't know, I was talking and I got a funny bad feeling, like I may have stepped on it.' And then I went down for a weekend, and he called me, and I said, 'Oh, I don't know. The first day went okay, I guess, but I just don't know. I just don't know.' " They both came on board that year.

"It really comes down to personality," Spruce says. "You know the pilot skills are there from the guy's peers. But can he get along with us? We're gonna be together a lot. And the flying is different. He could be a good stick, but demonstration flying is different."

Wooldridge recalls going out to dinner with the senior officers who would select him as the new Boss. "I think they ask their wives [about the applicants]," he says. "That's what we do. 'Any sneaky Petes?' we ask them."

If one of his junior officers hadn't pestered him, Wooldridge might never have tried for Boss. "I laughed him off. But two weeks before [the application] was due I thought, *I've got nothing to lose. If I pass this up, think what it would mean to me.*"

Now the armed services are being reduced in size, and there's a momentary excess of pilots. "The Russians didn't give us enough notice," says Rear Admiral Robert Hickey, the officer responsible for ensuring that the Navy has enough trained pilots. When the Soviet Union collapsed, it happened so suddenly that none of the services have had time to adjust. But even when the Navy does reduce its size, it will still need to recruit, says Hickey. "My biggest worry is that in *x* number of years—two or three—we're gonna have a requirement that we don't have people for. It's a sine wave, a roller coaster. Back in the '70s I was here in Washington and we were extending tour lengths."

What adversary future Navy pilots confront is anybody's guess, but for the Blue Angels, the Russians have become simply another audience. This year's unprecedented appearance in Moscow could even lead to an exchange demonstration.

Soon we'll know how the Blue Angels fare over Red Square. Of course, Stewart's narration will have to be translated. But they'll fly it the way they fly any other show, then they'll move on for the next date. On November 14, this year's team will fly its last show at Pensacola, Florida—home. The new team will spend the holidays with family and friends, and come January, they'll pack their bags for El Centro.



Giving out autographs to potential recruits is as much a part of a Blue Angel's job as flying.

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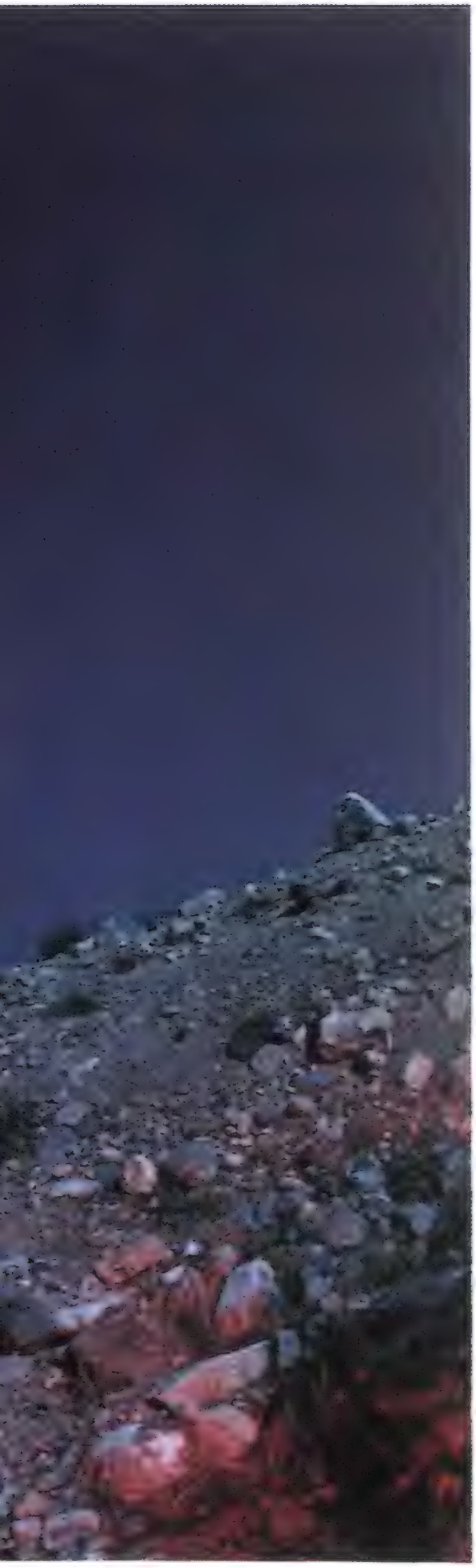
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LLING

When NASA spacecraft phone home, they call the Deep Space Network. And lately they've been getting a lot of busy signals.

by J. Kelly Beatty

January 24, 1986, dawned bright and clear in California's Mojave Desert, the rising sun bathing the four huge antennas of the Goldstone tracking station with neon pinks and oranges. Two of the cupped dishes seemed to stare back at the sun, but they were really focused on a much more distant object. Voyager 2 was nearing its historic encounter with Uranus, and the antennas were listening for the faint signals generated by the probe's 22-watt transmitter, nearly two billion miles away.

Inside the Goldstone complex, one of three sites in the worldwide tracking system known as the Deep Space Network, the atmosphere was tense but quiet. Then the early-morning routine was abruptly shattered. Giotto, a European-built probe on its way to a rendezvous with Halley's Comet, had inexplicably broken its radio link with the European Space Agency's antenna in Germany, and its managers needed NASA's help. With only 15 minutes' warning, the Goldstone team scrambled to swing their 34-meter (110-foot) antenna toward Giotto, while keeping its 64-meter (210-foot) partner fixed on Voyager 2. The European probe, controllers discovered, had turned slightly, and the signal reaching Earth was 300 times weaker than expected. It was a simple problem, soon fixed. Once again the Deep Space Network had demonstrated that when it comes to communicating with distant spacecraft, nobody does it better.

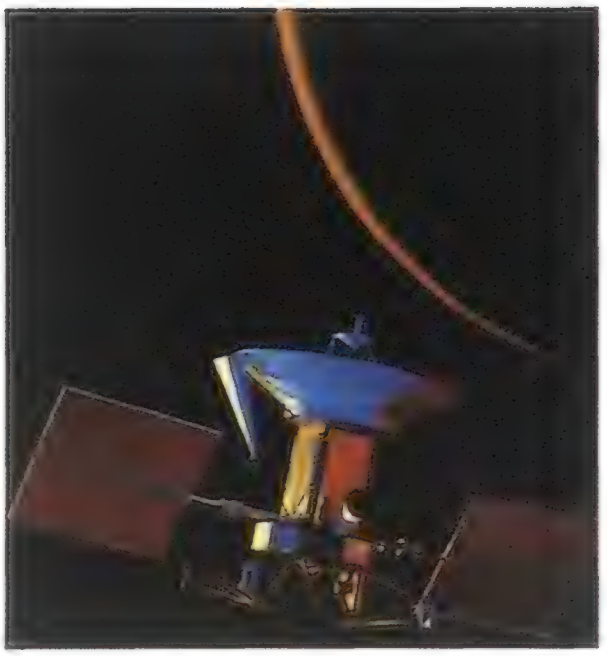
Yet the system, which tracks spacecraft, receives their data, and sends them commands, has become increasingly overburdened. Who would have predicted that Pioneer 10 would cross Pluto's orbit and still be sending back data 20 years after its launch? The two Voyagers, launched in 1979, carry on as well, probing the fields and particles at the edge of the solar system, and their scientists want to listen to them as long as they remain productive. In fact, last year the network's 14 mesh-and-girder antennas tracked a record-high 32 spacecraft. DSN managers realize that the competition for time on an increasingly breakdown-plagued system will worsen later this decade, when Galileo reaches Jupiter and NASA launches new missions to Mars and Saturn.

A Goldstone antenna in the California desert communicates with distant spacecraft. The data the antenna receives will be sent to DSN headquarters at Pasadena's Jet Propulsion Laboratory (below).



On top of all that, the network will soon scan the heavens for radio broadcasts from extraterrestrial civilizations. To meet the demand, NASA hopes to equip each site by the end of the century with up to three new 34-meter antennas and state-of-the-art telemetry systems, but Congress has yet to provide the necessary $500 million.

Little of this could have been forecast back in 1958, when the Army asked the Jet Propulsion Laboratory in Pasadena, California, to track Explorer 1, the first successful U.S. satellite. Shortly after NASA was created later that year, the agency set up the DSN, with three sites spaced around the globe so that future moon- and planet-bound spacecraft could always be in contact with at least one. The sites today are in California, Australia, and Spain. Almost from the beginning, NASA staffed the foreign stations with local engineers and technicians rather than U.S. personnel. It would prove cheaper in the long run, and the host countries preferred to use their own citizens anyway. That policy continues, and though each center does business the NASA way, its host nation's culture flavors the daily activities. At the Tidbinbilla facility in Australia, 25 miles southwest of Canberra, the station's 165 employees work for the Australian arm of British Aerospace, which in turn is managed by the Australian Space Office under an agreement with NASA. Spain's Robledo de Chavela station, 40 miles west of Madrid, was established in 1965 to replace the original site outside Johannesburg, South Africa. Today Spain's National Institute of Aerospace Technology provides a staff of 200, who work and sleep at the station in four-day shifts. It's a casual but distinctly male environment, with televised soccer matches and machine-dispensed beer and wine for off-duty hours. "It's not considered a U.S. facility at all," notes JPL's Jack Dawson. "They see this as Spain's entry into the space sciences, and they're proud to be there."





JPL (3)

The DSN's workload includes missions such as Magellan's radar-mapping expedition to Venus (right). Future tasks include receiving data from the probe Galileo will send into Jupiter's atmosphere (below).

Because the centers feel a sense of independence, they sometimes complain that the managers in Pasadena are too controlling. "We think we know as much about tracking spacecraft as anyone in the world," Australia manager Michael Dinn said recently. "We need to gently remind JPL of that from time to time." To demonstrate the level of instruction he gets from Pasadena, Dinn reached into his office wastebasket and pulled out a big sheaf of faxed messages and schedule changes that had arrived that morning.

In fact, the opinion is widespread that the DSN's handlers back in Pasadena are too set in their ways. "To call them conservative would be an understatement," says one former systems specialist. Managerial promotions usually go to insiders, and even those new employees who have first-rate technical credentials are looked upon as apprentices. "When I left the DSN," the specialist recalls, "I was shocked to discover that it wasn't the center of the universe."

Thus, the hiring of Larry Dumas in 1987 to take the network's reins was widely viewed as a positive step. Dumas was an "outsider"—though he worked at JPL he wasn't a DSN manager. "The general sense was that this was a self-contained, insular organization that did things by its own set of rules," says Dumas, who left the DSN in July to become JPL's deputy director. But Dumas adds that he didn't come in with a meat axe. "We've made some changes, but I've come to understand it's the way it is for a good reason," namely, he says, because so much depends on the network being able to function at peak efficiency as it continues to evolve. In Dumas' view, the DSN has to function differently from other NASA programs. "It's not unfair to describe us as a utility," he says. "We have a long-term multi-mission character that requires our operations to look slightly different. We're service-oriented, not project-oriented."

Eugene Burke Jr. (opposite) heads the committee that mediates disputes over tracking time.

Without that service, NASA's hundred-million-dollar probes would be little more than hardware talking to itself. The DSN's biggest dishes have nearly an acre of collecting surface and weigh 4,000 tons, yet can be pointed with an accuracy of 0.01 degree. The antennas routinely lock onto unimaginably weak spacecraft beacons—by the time the signal reaches Earth it may be no stronger than a billionth of a trillionth of a watt—which then have to be greatly amplified. In its early days, DSN amplifiers used vacuum tubes, which added a good deal of their own noise to the already faint transmissions. Today the best amplifiers use masers (microwave amplification by stimulated emission of radiation), which are cooled by liquid helium to operate at low temperatures that generate little interference.

Requests for tracking time on the DSN are about double what the system can support, and much of the data sent in from space simply cannot be collected. "There's no question that we can't fulfill all the missions, and it's been that way for years," says Raymond Amorose, who coordinates all of the DSN's mission support and operations. The network's Solomon of tracking disputes is Eugene Burke Jr., chairman of the Joint Users Resource Allocation Planning Committee, which meets weekly to try to resolve the conflicts that arise among projects competing for tracking time. "It's like trying to put 10 pounds of mission requirements in a five-pound bag," Burke laments. Master schedules, prepared twice each year, are built around key activities such as flybys, trajectory adjustments, and maintenance. They provide the foundation for thick printouts that will eventually detail every antenna movement, every trickle of data, minute by minute for eight weeks in advance. "It's a fairly complex issue here on how to distribute the resources to each of the users, whether they're flight projects or whether they're radio science or whether they're astronomy or whatever has to do with the using of the Deep Space Network," Burke says. "We try to reach a consensus on what we do."



Antenna time is divvied up as democratically as possible. Says Burke, "I just had a meeting with the project managers and mission directors of Pioneer [12] and Galileo and Voyager to try to get some of the conflicts worked out towards the end of this year, when Pioneer 12 is going to be entering [Venus'] atmosphere and Galileo is going to be flying by Earth again. So there's all kinds of different things going on during this time frame."

Spacecraft in their prime or at critical mission junctures get the DSN's undivided attention, while those that have finished their primary missions, like the Voyagers and Pioneers, generally lose out. So do radio astronomers, who like to use the antennas as big radar guns to ping everything from little asteroids passing near Earth to satellites of the outer planets.

At the individual centers, the trackers—officially called "link monitor controllers"—have a certain point-and-shoot rhythm to their daily routine that belies the operation's complexity. At each DSN site one person generally handles a single antenna for an entire shift. It can take an hour to ready a dish and its associated electronic systems before the targeted spacecraft pops up over the horizon. Meanwhile, a clutch of supervising controllers monitor the activity from the master control center in Pasadena. JPL's computers provide the basic recipe of pointing directions, receiver settings, and timetables, but it's up to the individual operator to make sure that any last-minute changes—most prevalent for orbital missions and those newly launched—are typed in and verified. All these preliminaries follow a tightly scripted timetable that leaves little margin for operator error,

Getting the Signal

When it comes to receiving data from space, says former DSN manager Larry Dumas, "the real challenge is signal strength. When it's extremely low it limits the data rate." That can be a serious problem when transmitting just one visual image can take up to five million bits of data. Because large antennas and powerful transmitters don't fit aboard tiny space probes, engineers have built spacecraft that focus the transmission beam and concentrate its energy. Beam size depends on the signal's frequency as well as the size of the antenna, so NASA has steadily increased its frequencies over the years. The first Explorers broadcast on frequencies of 100 megahertz (million cycles per second). Later, Rangers and Mariners used frequencies of around 890 to 960 megahertz, but they had to compete with airlines, which wanted to use the same bands. Now 2,200 and 8,400 megahertz are the standards, and future spacecraft will operate at 30,000 megahertz (30 gigahertz). Even with a narrow beam, though, the signal energy is greatly dissipated during its trip through space. "The 'footprint' of the beam is millions of miles across by the time it gets to Earth," says Dumas. To detect the weak signals, the DSN sometimes employs "antenna arraying," in which two or more antennas work in unison to capture the same transmission.

The network is also responsible for sending commands to distant space probes, a task with its own set of headaches. Although the DSN transmitters on Earth are much more powerful than those on spacecraft, the probes are normally programmed to accept signals on a specific frequency. Consequently, the DSN must compensate for factors like changes in the signal's frequency caused by Earth's rotation—an effect called a Doppler shift. Even temperature variations in a probe's receivers can result in a missed command.

Doppler shifts are important for the DSN's third major task, tracking. Measuring the Doppler shift in the frequency of a signal transmitted from a spacecraft enables trackers to calculate the craft's momentum in relation to Earth. The exact time it takes the signal to travel determines the craft's distance. Use of two-way Doppler, in which signals transmitted to and from the probe are compared, can nail down the spacecraft's distance—even across the solar system—to within 45 feet.



J. KELLY BEATTY/SKY & TELESCOPE

Astronomer Steve Ostro, here on Goldstone's 70-meter dish, uses the DSN to sound asteroids with radar.

a balky computer, or the outright failure of some piece of equipment. This "pre-calibration" sequence is the most stressful part of the job, says Goldstone training specialist Tim Gregor. "And when something goes wrong," he adds, "everything seems to snowball."

The most demanding of all observations are occultations—when a spacecraft beams its Earth-bound transmissions through another planet's atmosphere. The atmosphere distorts the signals in ways that allow scientists to determine the atmosphere's properties, but it also weakens the transmissions. Occultations can last for hours, and everything, particularly the antenna pointing, must work perfectly or the data will be lost.

The worst problems are those that happen in deep space, and a prolonged spacecraft emergency can destroy months of careful scheduling. Recently the network has been preoccupied with Galileo, a $1.4 billion spacecraft bound for Jupiter whose main antenna became snared while attempting to open in April 1991. Without it, communication with Earth has been taking literally thousands of times longer than planned. Even receiving a handful of navigation images from Galileo prior to its flyby of the asteroid Gaspra last October took nearly 300 hours of steady tracking with the big 70-meter antennas. "The rest of the projects who were originally utilizing the system have to try to move out of the way and fit Galileo in at that time," says Burke.



Other spacecraft have their own problems. In October 1990, the Magellan spacecraft, on a radar-mapping expedition to Venus, broke its routine by suddenly shifting to a backup amplifier when its main one shut down. Data was lost for more than half an hour before controllers noticed the switch. Voyager 2's receiver is so touchy that slight temperature changes can alter the frequency it listens for. Every time DSN technicians send it a signal, they must predict the receiver's temperature and thus the frequency it will accept.

Problems develop on Earth too. Weather causes trouble, with moisture in the atmosphere absorbing the signal or creating electronic noise that hides it. Veteran tracker Ben Ryan recalls that when Voyager 2 made its Jupiter flyby, a particularly fierce thunderstorm struck the Tidbinbilla site and degraded the incoming signal. JPL managers were pressing the Australians to come up with a solution. "What do you expect me to do?" Ryan snapped back. "Ring up God?"

However, most of the DSN's current terrestrial worries center on its deteriorating antennas, some of which are 30 years old. During the late 1970s and early 1980s, six of them were outfitted with bigger collectors to improve sensitivity—64-meter dishes were expanded to 70s, and three 26-meter instruments became 34s. These upgrades helped Voyager 2 reap bumper crops of data as it flew past Uranus and Neptune. But each antenna also became heavier—the large antennas gained up to one million pounds—and the support structures could not be beefed up to match, creating serious stress problems. The enlarged 26-meter collectors are now so top-heavy that they tear apart their drive gears, and a 60-mph wind from the wrong direction could send a dish crashing to the ground. In December 1989, a huge bearing on Robledo's 70-meter antenna self-destructed, knocking the instrument out of service for three months.

Meanwhile, NASA is unlikely to spend much more for system operations than the $195 million allocated for fiscal 1992. "Headquarters is continually concerned with finding ways to do more for less," says Dumas. In addition to building new antennas—or perhaps instead of building them—NASA managers hope other nations with large radio telescopes will agree to track U.S. spacecraft occasionally. The Japanese, who loaned out a 64-meter antenna for Voyager 2's Neptune encounter, have passed, for now, on sharing it again. But the Russians, who have a pair of 70-meter dishes sitting idle for lack of homegrown spacecraft to monitor, are keenly interested. "They want to track the Voyagers in the worst way," says Nicholas Renzetti, the DSN's science manager. "They want the prestige." Trial runs took place this spring.

Understandably, DSN station managers are under pressure to keep the existing system operating at peak efficiency. Moves toward automation, including a massive $100 million systems upgrade in the mid-1980s, eliminated hundreds of positions and pared the network's total workforce to roughly 1,000. But with mission spectaculars like Voyager in the past, tracking has become routine, less an adventure and more a business. Vic Sutton, a controller who's been at it for 14 years, says, "I started out with a career, but now it's just a job."

Yet NASA is still flying missions that no one else can, and the Deep Space Network is right in the thick of it. The schedule may call for saving a derelict spacecraft one day and hauling in a radio whisper from beyond Pluto the next. "We don't support a particularly U.S. or foreign spacecraft," Sutton explains. "We support the world's scientific community." He pauses to make sure his antenna is still tracking Ulysses, a probe nearly a billion miles away. "For us," he says, "the bottom line is good data, out the door, on time. Period."

Larry Dumas (above), who became JPL's deputy director in July, sees the DSN as a service-oriented utility.

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The Name



For fliers, *haute* nomenclature is a fine art.

by Elaine de Man

Illustrations by David Clark

Major Kathy White is preoccupied with Spirits, Ghosts, and Wraiths. Her day is filled with Rattlers, Diamondbacks, Predators, Terminators, and Killer Bees—just some of the names proposed for the Air Force's new F-22 advanced tactical fighter. White's job is to narrow the 100 candidates down to a precious few, which she will pass along to General John Michael Loh, head of Air Combat Command.

Some names, like Widowmaker, are "a little tacky" for serious consideration, says White. Others are too trendy, like Ninja, which today evokes images of sewer-dwelling combat turtles. Besides, in the current political climate, it would be impolitic to name an American aircraft after a Japanese assassin. Lockheed, one of the companies that is developing the F-22, proposed Lightning, the name of its World War II P-38, but Loh, who doesn't think his brand-new, state-of-the-art airplane should be named *after* anything, has ordered his staff to come up with names that have never flown before.



Lockheed S-3 "Hoover"

Loh will narrow the list he gets to three or four names, indicate his preference, and send the candidates along a paper trail that begins and ends at the Aeronautical Systems Center at Wright-Patterson Air Force Base in Ohio, which is responsible for coordinating the naming process. Loh's choices will be sent to the ASC's Standards Group, which keeps a record of the official names and designations for all U.S. military aerospace vehicles. The Standards Group will make sure that Loh's choices don't duplicate names of any aircraft still in service, then pass them along to the office of the Secretary of the Air Force, where the Judge Advocate General will do a trademark search. Next, they are sent to the Assistant Secretary of Defense for Public Affairs, whose office will ensure the "public suitability" called for by Air Force naming regulations before okaying or overriding Loh's decision and returning the list to the ASC. Presumably the process will be completed and the F-22 christened before it enters service at the turn of the century.

Lockheed F-104 Super Starfighter

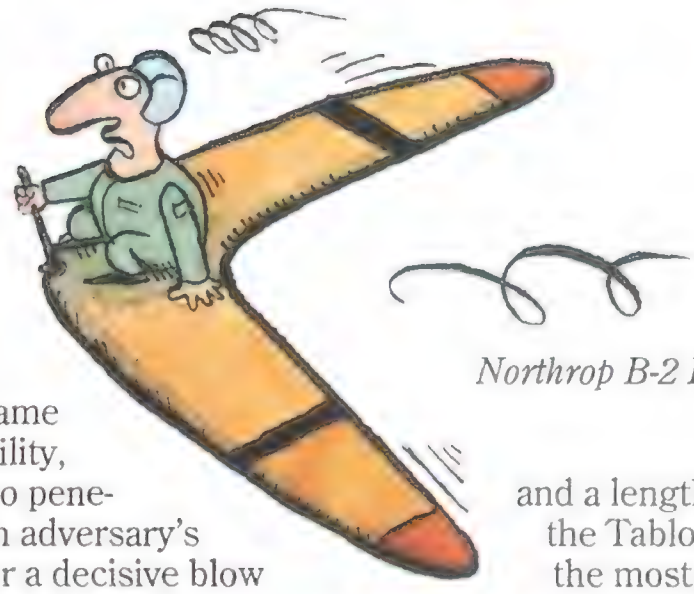


McDonnell F-4 Phantom

No one wants a replay of the Rockwell B-1B naming saga, which took nine years. After considering and rejecting hundreds of names, the powers that be finally managed to agree on an official title for the beleaguered bomber. It is now the Lancer.

It would probably still be called the B-1 were it not for the relentless efforts of Republican congressman

Game



Northrop B-2 Boomerang?

Robert Dornan, whose district at one time included Rockwell International's headquarters in El Segundo, California. Dornan, an ex-Air Force pilot, was convinced that a name could help the B-1's image problem. "Tradition demands that all U.S. aircraft have their own unique names," he wrote to Air Force secretary Donald Rice in 1989. "Not only does a nickname improve the morale of the men who fly the plane, but it gives the plane a 'personality.' As you know, it is easier to politically attack an alphanumeric generic plane, than it is to go after an aircraft with its own sobriquet."

Dornan began his campaign to name the B-1 in the early 1970s. At that time he proposed a handful of names, including Peacemaker II, but the Air Force, which had a proprietary interest in naming its own airplanes, didn't respond. Dornan revived his campaign in 1984, hoping to name the B-1B in conjunction with its rollout ceremony. But by then the public was not convinced that the new bomber was a necessary addition to the nation's arsenal, and the Air Force was concerned about "potential media problems" that a traditional name-the-plane contest would attract. It quietly came up with Excalibur, after King Arthur's sword, "a strong weapon with significant deterrent power," according to the Strategic Air Command. However, a trademark search revealed that Excalibur was already the name of an automobile, a car wax, and a condom. The Air Force decided to simply call it the B-1 for the time being.

On the next go-around, the Air Force, reluctant to give up the sword image, decided that Lancer invoked the "spirit of its mission." "Much like the Lancers of yesteryear," Air Force secretary Rice wrote to Dornan in 1990, "the B-1Bs of today provide the same speed, maneuverability, and shock needed to penetrate well beyond an adversary's defenses and deliver a decisive blow to his war fighting means."

That's the official Air Force view, but according to *The American Heritage Dictionary,* a lancer is merely a cavalryman armed with a thrusting weapon that has a long wooden shaft and a sharp metal head. In modern culture, the name brings to mind the cold surgical precision with which a boil might be treated, which would make Lancer more appropriate for an aircraft in the Tactical Air Command stable, like the F-117, which also awaits a name.



Britain's Hawker Tempest

Over the years the naming process has become mired in bureaucracy and guarded religiously by the military, but it began rather simply in 1913, when Great Britain named its new single-seat reconnaissance biplane the Sopwith Tabloid. Back then, "tabloid" meant anything in compressed or condensed form, and with a wingspan just under 26 feet and a length of 20-plus feet, the Tabloid was one of the most compressed and condensed airplanes of its day. By the end of the war, Sopwith, the leading proponent of nicknames, had turned out the Baby, Pup, Strutter, Cuckoo, Snipe, and the venerable Camel, which earned its name from the humped fairing that covered its twin machine guns. And the Sopwith Snail was named not for its performance but for its shell-like planked monocoque fuselage.

Across the Atlantic, the Curtiss JN-4, a trainer built for the U.S. Army, became known as the Jenny, an elongated acronym. It wasn't until 1925, when the Curtiss Aeroplane and Motor Company christened its P-1 the Hawk, that U.S. military aircraft began receiving names that connoted combativeness.

When U.S. involvement in World War II seemed imminent, the government encouraged the use of popular names as a security measure, since numerical designations tended to reveal the developmental and production stages of a particular aircraft. But manufacturers did not always come up with names that would strike fear in the heart of the enemy. It would be difficult to rally enthusiasm for an army of, say, Peashooters, the name pilots bestowed on the Boeing P-26.



Lockheed F-22 Killer Bee?

Curtiss named its XP-55 pusher-type fighter the Ascender, which sounded pretty high and mighty until one of its engineers turned it into a double entendre mocking the aft-engine configuration. In 1943 the Army Air Forces' Sub-Committee on Standardization of the Joint Aircraft Committee begat the Technical Sub-Committee on Naming Aircraft to dignify the whole process.

High on the list of priorities were the publicity value and propaganda



Fairchild A-10 "Warthog"

power of aircraft names. Fighters, according to the new policy, should have names "indicating speed, maneuverability, fighting characteristics and aggressiveness," and soon the nation was rallying around fighters named Black Widow, Kingcobra, Lightning, and Thunderbolt. Bombers were to have names indicative of their "size, weight, power, range or destructive characteristics," and thus various bombers were christened Vengeance, Avenger, Marauder, Invader, and Liberator. (The sole concession to sentiment was the North American B-25 bomber, which was named the Mitchell after General Billy Mitchell, a zealous air power advocate who died in 1936.)

The policy allowed manufacturers an option to reserve a series of names for future models. Douglas had dibs on the Sky- prefix and produced the Skyhawk, Skyknight, Skymaster, Skyraider, Skytrain, Skytrooper, and Skywarrior. Grumman requested Wildcat for the F4F and reserved -cat for good measure, which led to the Hellcat, Tigercat, and Bearcat. (Bearcat was initially rejected because, according to the naming subcommittee, "a bear is a big and lumbering animal and does not possess the characteristics of speed and aggressiveness expected of a small fighter aircraft.")

Even the British, who initially dubbed the Grumman Wildcat fighter the Martlet, were swayed to endow their aerial fleet with names more befitting a nation under siege. The pastoral Flycatchers, Gamecocks, and Grebes of the 1920s were replaced by Tempests, Typhoons, Hurricanes, and Spitfires.

In the 1960s the general tone of aircraft names took a dramatic turn to counter negative images resulting from the Vietnam War. The McDonnell Douglas F-15, whose predecessors had been given such supernatural names as Banshee, Demon, Phantom, and Voodoo, was christened the Eagle, a more uplifting and patriotic name. The General Dynamics F-16, whose pilots had wanted it named Viper after the fighters in the TV series "Battlestar Galactica," was named the Fighting Falcon. By now, manufacturers had pretty much lost all control over the naming process, which had evolved from a somewhat spontaneous verbal tradition into a laborious, paper-shuffling exercise, governed by Department of Defense regulation number AFR82-1/AR70-

Northrop P-61 Black Widow





Rockwell B-1 "Bone"

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Today, both the Air Force and the Navy are finding it difficult to come up with new names. "I think in the future we'll see more airplanes named 'II,' like the Phantom II," says William Armstrong, Naval Air Systems Command historian. Aircraft names have also run the gamut of Supers, as in Superfortress, Super Sabre, and Super Starfighter. Even so, one of the names in the running for the F-22 is Superstar—"a ridiculous name," says an industry source who requested anonymity.

While the brass pushes papers from one office to another, pilots and crews come up with their own names for aircraft once they start flying. Such nicknames, according to one Air Force historian, "ooze out of the mire of popular culture." B-52 crews, whose airplane the Lancer was designed to replace, refer to the B-1 as the Lawn Dart, which conjures an image of that long wooden shaft with a sharp metal head planted in tall fescue. Pilots bestowed the same name upon the Air Force's F-16 in the early days of its "operational experience" when it too was falling out of the sky at an alarming rate. Another nickname was given to the B-1 by a reporter who carelessly left out the hyphen and spelled out the 1, resulting in a story about the Rockwell Bone bomber. B-1B crews adopted the error and recently started up an informal organization called the Fraternal Order of the Bone.

On board the nation's aircraft carriers, the Grumman F-14 Tomcat is called the Turkey. According to Bill Flanagan, a Northrop engineer and

amateur aviation historian, it's partially a reflection of the airplane's overly busy appearance when landing, but it's backed up by an early history of decidedly unresponsive flight characteristics. "The first F-14s, despite all the initial propaganda about what great dogfighters they were supposed to be, were underpowered and in reality they were not that great," says Flanagan.

According to Peter Kirkup, Grumman's historian, the Tomcat was named to evoke a scrappy little fighter. The name also complied with the Grumman cat name tradition initiated during World War II. The urban legend in Washington, however, is that the Tomcat was named for Vice Admiral Tom Connolly, who fought long and hard for the airplane. "An unsubstantiated rumor," says the Navy. "A lucky coincidence," says Grumman.

The enduring and endearing nicknames are the ones based on appearance. Hardly anyone knows the Fairchild A-10 as the Thunderbolt II.



Britain's Sopwith Camel

It is the Warthog, and its pilots call themselves Hog Drivers. And no one calls the Boeing B-52 the Stratofortress. It is the BUFF. It lives at a BUFF base, and it is flown by BUFF drivers. BUFF stands for Big Ugly Fat Fellow, or, depending on whom you are talking to, a more vulgar noun.



Douglas A-3B Skywarrior

The General Dynamics F-111 is known as the Aardvark, presumably because its long, droopy nose resembles that of an anteater. Flanagan, however, claims there's another reason. "They had a lot of engine problems with the F-111 in its early days," he says, "and it spent much of its time hugging the ground, so a weapons system officer at Cannon Air Force Base came up with the name Aardvark, which actually means 'earth pig.' "

Aardvark has gained such popularity that many people assume it is official, but the F-111 is one of the few airplanes in the military inventory that has never been officially christened. General Dynamics lobbied for the name Dynasweep to highlight the aircraft's swing-wing configuration, but perhaps because the name was more suitable for a vacuum cleaner than a state-of-the-art fighter, the Air Force declined. However, the Lockheed S-3 Viking sub hunter, which actually sounds like a vacuum cleaner, is unofficially known as the Hoover.

When the Lockheed SR-71 emerged from its security blanket, pilots nicknamed it the Sled—as in Lead Sled—because of its rate of climb was sluggish compared with that of its Lockheed U-2 predecessor. Neither aircraft received an official name, but the SR-71 became widely known as the Blackbird. In the surveillance community, however, Blackbird refers to both the U-2 and the SR-71.

Pilots of the SR-71 came to prefer the name Habu. "The Okinawans came up with that," says Buddy Brown, one of the first pilots of the U-2 and SR-71. "They thought the plane resembled a black poisonous snake they have there called the Habu. And they called us Habu pilots." When the crews flying the Boeing KC-135 Stratotanker, which has a surplus of unofficial nicknames such as Silver Sow, Porkus Subsonicus, and simply Hog, caught wind of this, they assigned the name Hogu to the KC-135Q, which refuels the SR-71.

Now that the future of the Strategic Air Command's Northrop B-2 bomber is somewhat secure, naming the craft will become a priority for Congressman Dornan, in whose state it will take shape (he's lobbying for Shadow). Several years ago the name Stealth won an air force name-the-plane contest but was rejected because of potential confusion with the Tactical Air Command's F-117 Stealth fighter, an unofficial name bestowed by the media. Not only that, a condom company beat them to the punch once again. Meanwhile, B-2 test personnel at California's Edwards Air Force Base have come up with a few nicknames of their own, like Manta Ray and the Boomerang Bomber (It Always Comes Back.) What's unclear is whether they mean it's returning for Congressional approval or repair.



Grumman F6F Hellcat

"THIS IS BOBBY YON, ALTHA



AIR SERVICE"

Somewhere below the power lines and above the beggar weeds, one crop duster plies his trade.

by David Savold

Photographs by Bud Lee

A half-mile down from the peanut mill on a two-lane Florida blacktop known as 69A, a white plastic container hangs in the power lines. Years ago, the empty gallon jug had been full of a fungicide called Bravo, which local farmers use to keep leaf spot out of their peanuts. Now the container has another function: keeping crop dusters out of the power lines.

The Bravo jug is also a convenient landmark when Bobby Yon needs to tell visitors how to find his place. Directly below the empty jug is one end of a 2,500-foot grass runway, which belongs to Yon and his Altha Air Service. For better than two decades Yon has been in the crop dusting business, flying various airplanes, mostly Grumman or Schweizer Ag Cats, over fields of peanuts, soybeans, wheat, and cotton,



The road to Altha Air Service ends in a small herd of buildings and vehicles, where crop duster Bobby Yon (at right, above, with his water truck) runs an often risky, occasionally rewarding business.

trailing a wall of liquid spray from wingtip to wingtip.

But this isn't an especially auspicious time to be calling on the crop duster. He's got 600 acres of wheat to spray, and less than 24 hours ago the engine of his only airplane, a 1968 Ag Cat, caught fire, destroying the yellow and gray biplane. Its charred frame sits in the center of a section of blackened grass less than a hundred yards from the front door of Yon's trailer.

As he later describes the fire to the insurance man, his voice rolling with the lilting cadence of a life in rural Florida, "It like to burnt the world up."

Fifty-three years old and wearing a belt buckle that says "Old pilots never die, they just become taildraggers," Bobby Yon personifies the industry's old school. An independent breed with the toughness and resiliency of a looper caterpillar ("You can't kill 'em with a hammer," he says), his type is increasingly giving way to a younger generation of fliers known as "ag pilots."

To Yon, an ag pilot is "one that wears his leather jacket, and goes to the conventions, and wants to look pretty. I wear my old faded dungarees, my old gray shirts, and my dungaree jackets, and I don't want to impress nobody; I'm a crop duster. That's me."

Yon was born and raised only a few miles from here, some 50 miles west of Tallahassee, where palmetto palm mingles with yellow pine. Life in Altha, a sleepy little town of about 500, is quiet and fairly free of problems, he says, save for a recent influx of Yankees.

Better than six feet tall, Yon appears at first glance to be in good physical condition, although up close, burn scars are faintly discernible. As recently as yesterday he burned himself on the exhaust system of the Ag Cat's nine-cylinder engine. The inside of his forearms have orange iodine spots that match the color of the kumquats he's eating.

Yon makes his home in the trailer at the end of the dirt road that runs alongside his runway. The day after the electric company ran power lines out to the trailer, Yon accidentally flew through the wires and tore them down. When the utility folks asked him what happened, he told them, " 'Well, some crazy crop duster done run into it.' I never did tell them it was me. But you know I told you, all the boys up there, they already knew me—*they* knew. They came down here and spliced the wire and didn't say a word." It was his buddies at West Florida Electric who hung the Bravo gallon jug in the power lines over his runway.

Yon worked in the insurance business and spent a couple of years farming before he got into crop dusting. Unlike many crop dusters of his generation, he didn't learn to fly in the military. "No, I bought every minute of time I got," he says. "That's the onliest regrets I got, see. It took me 10 years to get



Power lines are the bane of a crop duster's existence (left); so regularly do the two tangle that most ag planes are built with sharp-edged landing gear struts designed to cut through wire.



Both a uniquely individualized office (above) and the crop duster's home (below), Yon's cluttered trailer serves as the hub of his operation.

enough money to get in this business."

His first season Yon started off flying an Aero Commander A9B Quail, using county roads as his landing strips. The first field he sprayed had been planted with peanuts, and when he later went back to look at them, "it scared me to death." He thought he'd oversprayed and burned them up. "They looked like a paper sack," he says. But a peanut is a tough little plant. He kept going back and checking the field, and sure enough, in a few days he began to see a little green. To his relief, in about two weeks you couldn't even tell the crop had been sprayed. "I could just visualize me buying that patch of peanuts," he says.

Yon still takes off and lands on "little old highways where you won't see three cars all day long." He has a two-ton truck with a 300-gallon gas tank and a thousand-gallon water tank he parks on the road next to the field he's spraying. He pumps chemicals directly from a drum into his airplane, then adds the appropriate proportion of water from the truck.

The term "crop duster" really is a misnomer, since liquid chemical has pretty much taken over. When he first went into business Yon was using about half dust and half spray. He had his worst experience with dust when he was spreading sulfur over a field near the Georgia border. He was flying an oval-shaped pattern—racetracking—to let the dust settle. But despite his precautions, dust and sweat got in his eyes and he could barely see to land.

"You ain't never been sick unless you been sick on chemical," Yon says. Early on he had a nasty run-in with an insecticide called methyl parathion, which is used to kill caterpillars that get in the soybeans. "I just got a few whiffs of the fumes," he recalls. "I sat down on a bucket and there were drops of sweat on my head as big as the end of your finger. I couldn't get up. They had to help me up. I was done rattling in my chest. I was scared. I couldn't even hold my head up.

"I'm real careful now," he says. "I got respirators, I got rubber aprons, but if you got any sense you don't even need all that stuff. All that stuff will do is make you sweat, and then, if you get a little chemical on you in that sweat, it goes all over you in a hurry."

Ask Yon how high he flies when he's crop dusting and he holds the palms of his hands about 12 inches apart. "That high," he says. "You know, a beggar weed will get up two foot high. Well, I've come back with beggar weeds on my wheels."

It's that kind of flying that gives crop dusters more than a passing acquaintance with power lines. Yon says he once cut off the electricity in a 50-mile swath from Chattahoochee to Panama City, Florida. He was spraying a field he'd sprayed before, but a wire that cut across a corner of the field still took him by surprise. "I hit the wire and I broke two [utility] poles off and jacked two out of the ground and had all the wire from pole to pole and drug it into the wooden pole transmission line, which it burned all the wire up. And I seen two balls of fire about this big around"—he holds his hands to indicate something a little larger than a basketball—"and all that wire just disappeared. They didn't even fall in the soybeans, it just melted it. I don't know how many volts is on one of them transmission lines, but it burnt little holes across that wing. Looked like a little woodpecker been down a tree."



It's raining now. The day has been overcast from the beginning and thunder rumbles in the distance. A brown lizard hangs on the window screen inside the trailer.

The insurance adjustor from Tampa arrives by late morning to get a statement. "That airplane will cost $70,000 to replace," says Yon. "You know how much insurance I got on it? Thirty-six thousand dollars is what I'll get."

While the insurance man waits for the rain to let up so he can go outside and take pictures, he remarks on the Louis L'Amour paperbacks that are piled all over the trailer. Yon asks him if he wants to swap.

"What worries me is in this kind of weather the farmers can't plow," Yon says. "And when they can't plow they

can't plant. And if they can't plant, I can't spray. We've had two years here that has killed us. Year before last it rained and the people couldn't get their crop in. If it rains this year like it did last year, we can all hang it up."

Yon's mechanic calls. He's heard about a pilot in Alabama who might be available to help with the spraying. Yon jots down the number and makes the call: "R.D. was telling me that you might be interested in relocating a little bit," he says to the pilot. "I got a good business, I'm telling you. You know where the notch is in the panhandle? You know when you come across the panhandle it goes up towards and joins Georgia and Alabama at Chattahoochee? I'm just a little bit to the west and a little bit south of that notch."

Yon's mother calls. Does he want to come for dinner? (And of course the insurance man is welcome.) The rain ends and when the adjustor has finished, they pile into Yon's 1985 Buick Century and head out to the house near the Chipola River where he grew up and dived for arrowheads as a kid. Yon says grace and everyone sits down to a meal of sucker fish, doughbread, sweet potatoes, biscuits served with Tupelo honey, and iced tea. A couple of helpings later, it's time to get back to Yon's trailer; the insurance man's got a flight to catch.

The burned-out Ag Cat sitting in front of the trailer will provide Yon with another snapshot he can add to the wall behind his desk, which is covered with pictures of his relatives and his airplane wrecks. A couple of years ago, he lost an Ag Cat Super-B in a fire. A twister got a Piper PA-18 Super Cub. An Ag Cat A model with wing extensions ended up in a swamp.

Considering the risky altitude at which crop dusters fly, it's not surprising that the accident rate for the industry is higher than that for general aviation overall. What is surprising is how relatively few of those accidents are fatal. The National Transportation Safety Board reports that in 1988, the latest year for which figures are available, the number of fatal accidents in agricultural aviation was only about one-third that of general aviation overall, a testimony to the durability of airplanes made for agricultural work.

Yon had his worst crash in 1974, when he was flying a Super Cub. He was making his third pass over a field when a gust of wind caught him. The Super Cub hit a pecan tree, slammed into the ground, and caught fire. Yon came out of that one badly burned, with a leg broken in two places and a shattered kneecap. Eighty-eight days later he left the hospital in a body cast.



In a realm of flying fraught with hazards, crash helmets are a standard piece of crop duster apparel.

"You know I had a $25,000 hospital bill staring me in the face, and I had made $3,480 that year before I got hurt—that was my flying commission," he says. "So you can imagine what kind of state I was in. But I come out of the hospital and I borrowed $1,500 from my aunt and bought an Ag Cat in Arkansas I'd never seen. I bought it over the phone." He was back in business.

In good years, a crop duster's income can hit six figures. But business has been slack lately, especially in Yon's corner of northwest Florida. Only two crop dusters are left in an area where there once had been almost a dozen. One of them was busted for running dope, one got married and returned to his home state of Mississippi; hard times or bad business decisions drove almost everybody else out of business.

"The worst thing that hurts me is that the farmers are in trouble," says Yon. "And when the farmers are in trouble,



Yon lost his last airplane not to a crash but to a fire (left); now he waits for a replacement.

"All I want to know is how to survive," the pilot says of the many years he's spent flying over Florida farms (right).

the first one that suffers is me." Now the farmers are trying to save money by using ground rigs to put out chemicals, and Yon doesn't get the work he used to. Crop dusters nationwide have been faring similarly. In the 1970s approximately 10,000 agricultural airplanes were in use; today, that number has been nearly halved.

"If the crops got to where they brought a good price and everything...I'd be going from daylight to dark," Yon says. "That's the way it used to be, and that's the way it would be again."

Back when times were better, he had 60,000 acres to fly and needed three airplanes and extra pilots to do the job. He would be up before dawn, checking his airplanes with a flashlight, and was always running two pages behind on his worksheets. And when he crawled out of his airplane at the end of the day, he had to hang onto its side before his shaky legs would hold him up. "Then," the crop duster says, "you kept the airplane in the *air*."

A month after the fire, Yon still doesn't have an airplane in the air. But he's located one to buy. It's too late for spraying wheat and too early for spraying peanuts, so he's biding his time and waiting for the price to come down. In just a matter of weeks Altha Air Service will be in business again, once more flying inches above the sandy loam of the Florida panhandle.

An answering machine sits on Yon's desk next to the worksheets, Bible, insect spray, ashtray overflowing with Winston butts, tube of Ben-Gay, and the mail. When he's out working off some highway and a customer calls, the machine answers: "This is Bobby Yon, Altha Air Service. I'm unable to be at the phone at this time. If you will leave your name and number, I will return your call as soon as possible." Yon's gentle southern voice will fill the empty trailer and travel along one of the wires strung over his grassy field.



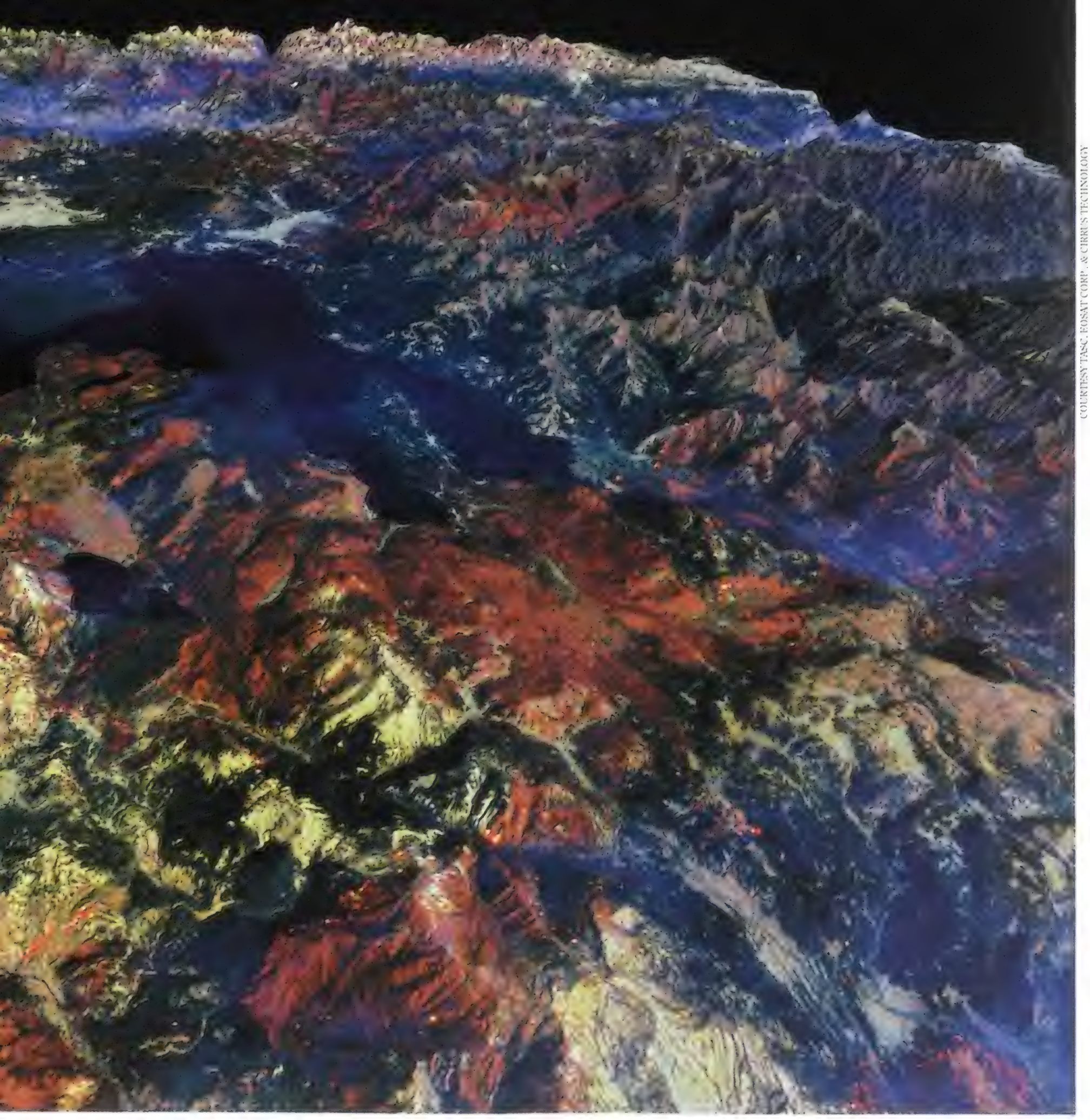


The view from above has always revealed a world of magnificence, subtlety, and danger.

Looking at Earth

by Priscilla Strain and Frederick Engle

Serialized from Looking at Earth, *the National Air and Space Museum, Smithsonian Institution, Turner Publishing, Inc., 1992.*



COURTESY TASC, EOSAT CORP. & CIRRUS TECHNOLOGY

Sometimes the only way to understand what's happening in the world is to rise above it. In ancient times travelers would hike up hills and soldiers would climb towers to better observe the land and prepare for obstacles or dangers. Today aircraft and spacecraft look down on Earth and provide new perspectives on changing populations and ecosystems, as well as on the beauty and symmetry of landscapes we might otherwise take for granted.

The use of instruments to gather data from above dates back to the late 1850s, when photographers took their early cameras up in balloons. The first to achieve success was the French photographer and publisher Gaspard Félix Tournachon (also known as Nadar), who produced a crude aerial photo of the outskirts of Paris in 1858. Kites and even pigeons were also used in early attempts at remote sensing.

The airplane provided a far more effective platform for looking down on Earth. One early model to be used this way was the open-cockpit de Havilland DH-4 biplane, which flew as both a bomber and a photo

When fires ravaged Yellowstone National Park in 1988, computer scientists produced this view of the area by combining satellite and topographic data (yellow specks: active fires; orange: burnt areas). Seventy years earlier, photographers used airplanes like the Curtiss Jenny (inset) to get overviews.



FRANS LANTING/MINDEN PICTURES

reconnaissance vehicle during World War I. After the war the DH-4 continued to provide aerial photographs, flying reconnaissance missions for the U.S. Geological Survey.

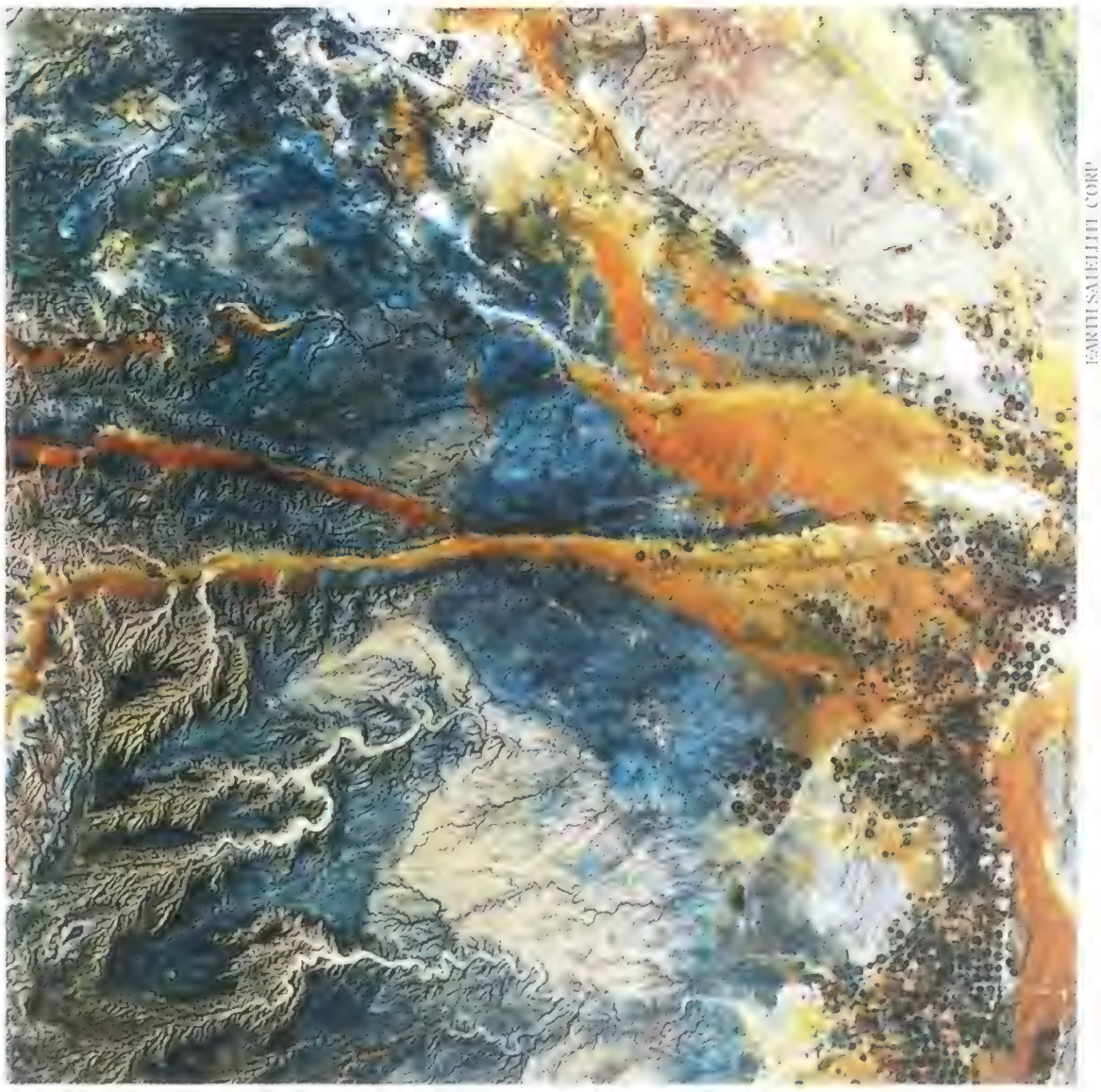
In later years, aerial photography found more and more uses. After a severe earthquake, for instance, rescuers would use photos taken from airplanes and helicopters to identify the sites in most desperate need of assistance. And in 1962, when underground coal fires broke out around Centralia, Pennsylvania, aerial heat-detecting imaging systems revealed those areas of the ground that were warmer than normal, enabling workers to target their fire-fighting efforts.

Aerial photography has also served the public in less obvious ways. In 1979, when workers constructing a recreational park on Neville Island, Pennsylvania, fell ill, public health officials suspected that some toxic substance was to blame. By studying aerial photos of the island from as far back as 1938, they discovered pools and trenches where hazardous solid and liquid wastes had been dumped for years.

Astronauts on the Gemini missions of the 1960s took the first photographs from space used to study Earth's large geological structures. Those successes paved the way for other space photography missions, and they also helped inspire another kind of imaging effort, the Landsat (for "land satellite") program. Since 1972 five Landsat spacecraft have been sent into orbit around Earth, equipped with imaging systems that collect data in different wavelengths of the electromagnetic spectrum. Today Landsats survey soil for erosion and moisture, monitor droughts, map flood plains, explore for oil and minerals, observe the circulation patterns of oceans, track wildlife, and measure pollution.

Each Landsat uses an oscillating mirror that scans Earth's surface from west to east. During these scans, rows of detectors measure the intensity of energy reflected or emitted from the surface and encode this information as a series of 0s and 1s (binary signals) to be transmitted back to Earth. This process produces what is known as digital imagery.

Digital images are different from conventional photographs. For one thing, a digital image's colors are "false"—computer scientists assign the data from each wavelength a primary color (red, green, or blue), then overlay the results to produce a composite image. Though the colors do not necessarily correspond to those the human eye would see, these pictures are nonetheless informative. Red, for example, usually represents near-infrared, and information gathered in these wavelengths



EARTH SATELLITE CORP

A Landsat satellite captured this portrait of the wadis*—dry stream beds—that snake across Saudi Arabia's Najd plateau. Though extremely arid, the region is nonetheless habitable, in part because groundwater-fed irrigation systems have been set up in the area at lower right.*



NASA

Photos of Madagascar expose the costs of intensive cultivation. An airplane-eye view shows hills denuded of vegetation (left), while a photo taken from the shuttle (above) reveals sediment flowing into the Mozambique Channel.



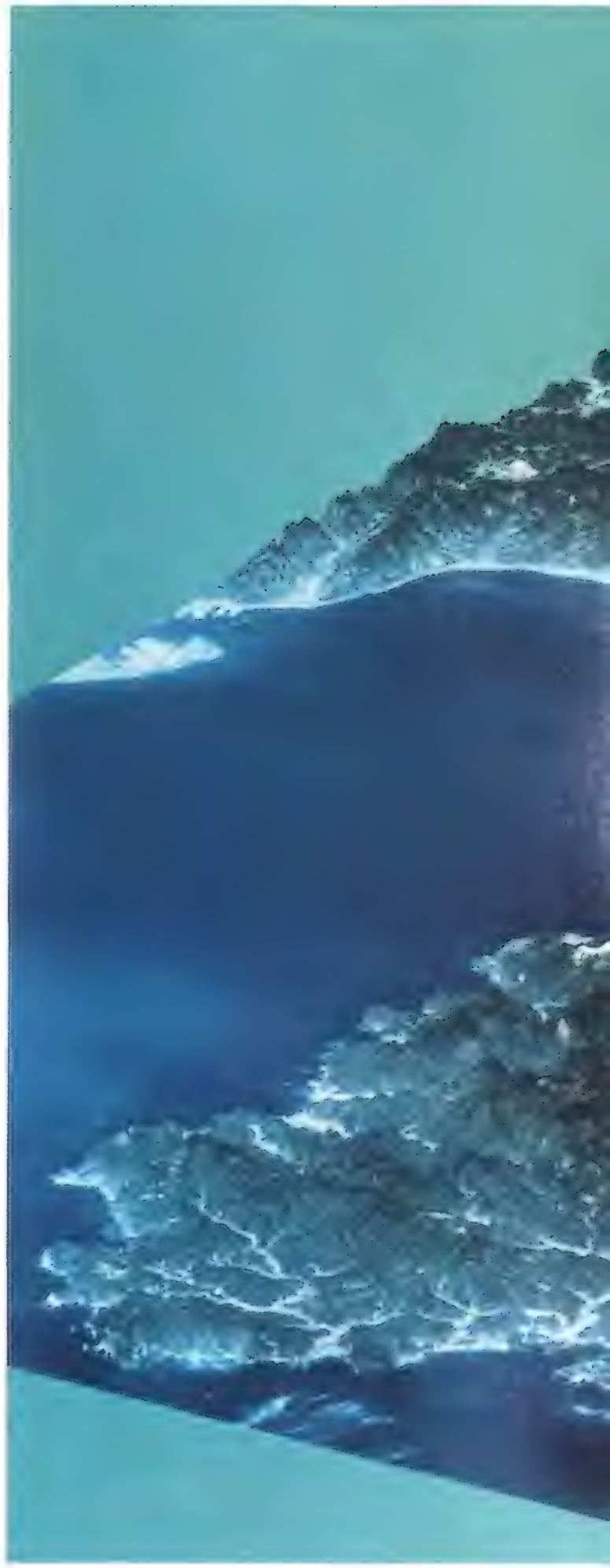
© 1991 CNES, PROVIDED BY SPOT IMAGE CORP

Combining information from both visible and thermal wavelengths, the image at left shows the intense heat (red) Chernobyl nuclear reactor no. 4 produced when it exploded in 1986. Today the reactor is encased in cement (below).



STEVE RAYMER

Antarctica's difficult terrain makes ground surveys nearly impossible; aerial photography and satellite imagery are more effective for mapping huge ice sheets and remote ice-capped mountains.





COLIN MONTEATH/HEDGEHOG HOUSE, N.Z.

indicates the health and vigor of crops and other plant life, with bright red representing healthy vegetation and lighter red and pink showing vegetation under stress.

Satellites like those of the Landsat system are classified as passive remote-sensing devices because they measure energy naturally reflected or radiated from Earth. Radar is an active sensing system: it provides its own signal, bouncing it off a target, such as an aircraft or a mountain, and recording the returning signal. Because radar systems



RESTON/MIHON UNIV

do not rely on sunlight and are not hampered by cloud cover, they can operate day or night and in any weather. This makes them especially useful in tropical areas, where clouds nearly always block the view of passive sensors. Radar has also proved useful in arid regions. Radar imagery of desert lands has located ancient waterways now dry and covered by sand. Last fall, archeologists using radar and other satellite imagery discovered old caravan trails that led to the remains of a long-lost city in Oman—possibly the fabled trading center of Ubar, which flourished more than 2,000 years ago.

Over the last two centuries, humankind has ventured progressively farther into the heavens, pursuing ever more challenging adventures. Today, at the end of the 20th century, more than 200 men and women have flown into space, a score having traveled as far out as the moon. Yet for many who have participated in these exciting voyages, the best part of all was looking homeward.

Landsat imagery was superimposed on topographic data to produce this 3D view of Japan's Mount Fuji. Such a clear image of Fuji's summit is rare; usually the peak is shrouded in clouds.

WILLOW RUN

When Henry Ford was finally persuaded to build B-24s, he did it his way—mass production at full throttle.

by Don Sherman

The American way of life is secure at the Orange Lantern roadhouse in Ypsilanti, Michigan. The tavern, a rambling building covered with pink siding, has been operating since 1934, when Prohibition ended in Michigan. There's Stroh's beer on tap here, not Dortmunder or Kirin, and the parking lot is filled with late-model pickups driven by local hourly auto workers. It's a homey pub, and the patrons can rest their elbows on a century-old Brunswick bar, air their gripes, and debate the issues of the day.

About two miles from the Orange Lantern, a creek named Willow Run passes lazily through what was once woods and gently rolling fields. Henry Ford bought the property adjoining the creek in 1931, and after farming it for a few years, he established Camp Willow Run to instill his brand of work ethic in sons of dead or disabled World War I veterans. On the 300-acre farm, such underprivileged youth lived in army tents, earned two dollars a day, and shared the profits from the fruits and vegetables they grew and sold on the site. But Henry Ford's boys' camp lasted only two years. A world war loomed, and the pastoral tranquility of the area yielded to the urgent need for Detroit's help in defending American interests.

At the outbreak of World War II, Henry Ford was an elderly, unpredictable man riddled with contradictions. He was far ahead of his time in paying workers five dollars a day, but he resisted to the bitter end their efforts to unionize. He was often spiteful toward his only son, Edsel, but never failed to dote on his four grandchildren. Although he saw involvement in a European war as part of a conspiracy against him and his company, Ford tempered his stand when the Nazis swarmed across the Continent in 1940. He despised war on moral grounds and cited George Washington's warning against foreign entanglements as justification. Although he became one of the most prolific armament producers in history, he converted his plowshares to swords only with great reluctance.

President Franklin Roosevelt believed war was coming and with it a need to bolster the nation's security. In May 1940 he called for an increase in aircraft production to 50,000 airplanes a year—roughly 20 times the increase in fleet size he'd asked for just one year earlier. Ford responded with the startling proclamation that "with the counsel of men like [Charles] Lindbergh and [Eddie] Rickenbacker and without meddling by government agencies, the Ford Motor Company could swing into a production of a thousand airplanes of a standard design a day." Edsel, the company's president, reminded skeptics that the Ford Motor Company had been an aircraft manufacturer from 1925 to 1933, though the old Tri-motor was hardly a model for modern airplanes.

Even after Henry Ford agreed to assist in the wartime effort, he continued to insist that the machines of war be used only to defend the United States. Back in Washington, the Commission for Industrial Production wanted Detroit to build not airplanes but aircraft engines and subassemblies. In June, Edsel returned from Washington with a contract to manufacture Rolls-Royce aircraft engines under license, an arrangement that his father initially condoned and later condemned because most of the engines were destined for England. Ford turned down the job, and Packard ended up building the Merlins. A few months later the elder Ford accepted a contract to build 4,000 Pratt & Whitney engines for U.S. aircraft.

In January 1941, at the behest of the Advisory Council for

No mass-produced bomber ever carried a "made in Detroit" label until the onset of war brought the B-24 to town.





COURTESY CHARLES SORENSEN COLLECTION (2)

Commuters on the freeway to Willow Run filled every available seat—gas was rationed (top). Notices recruited workers from all corners of the nation. Charles Sorensen, here examining a Ford-built engine, was a tough taskmaster with a brilliant grasp of production (bottom right).

National Defense, Ford executives were invited to visit Consolidated Aircraft in San Diego, California, with the hope that Ford might expand its involvement in aircraft production. Henry Ford had made it clear he wasn't interested in working with any aviation company, but Edsel made the fateful journey anyway, accompanied by Ford manufacturing boss Charles Sorensen.

Sorensen had begun his career at Ford in 1905 as a $3-a-day pattern maker. The Danish immigrant was Hollywood handsome, with a commanding stature, piercing blue eyes, and swept-back blond hair. Associates admired his quick mind as much as they feared his hot temper. Sorensen had stood steadfastly at the old man's side through it all—development of the Model T, adoption of the assembly line, construction of Ford's sprawling Rouge complex where every day iron ore went in one end and thousands of cars rolled out the other. Sorensen's persistent use of castings (instead of more expensive forgings) and the innovations he brought to that manufacturing process won him the nickname "Cast Iron Charlie" from his employer.

The Ford executives were polite to their hosts, but Sorensen in particular was not impressed with the methods used to produce the new B-24 Liberator bomber. (Final assembly took place in a steel fixture outside the plant in the California sun!) In his memoirs he observed sourly, "What I saw reminded me of the way we built cars at Ford 35 years earlier. Here was a custom-made airplane, put together as a tailor would cut and fit a suit of clothes."

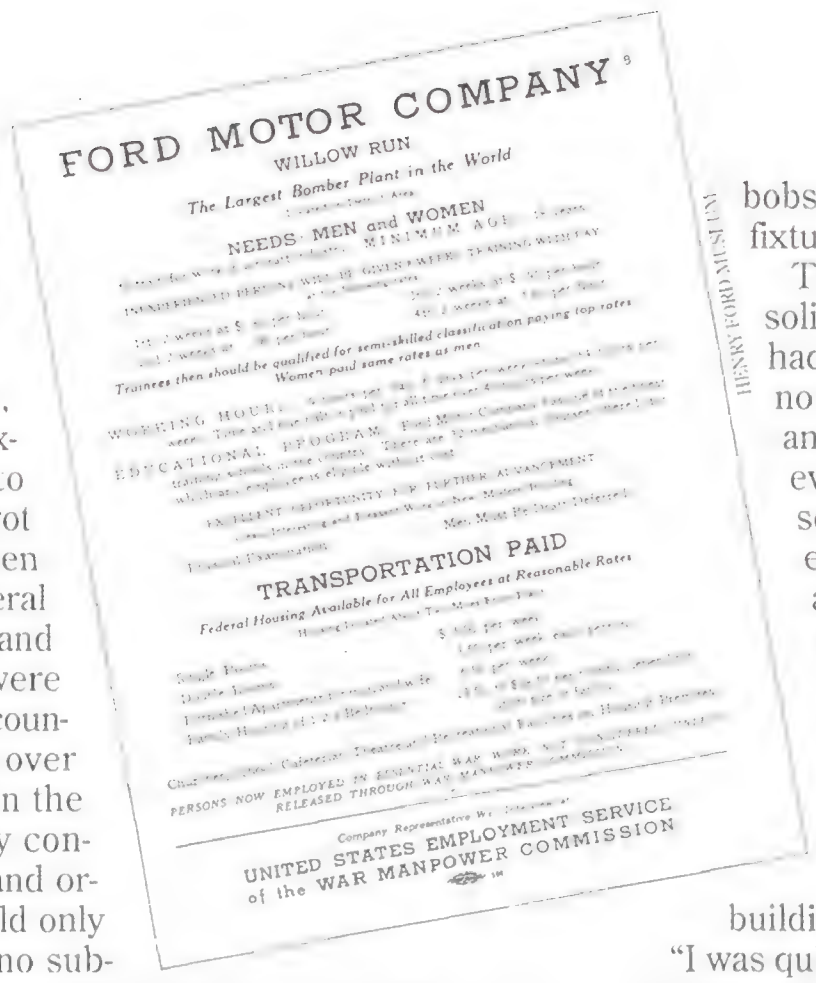
Sorensen was convinced that precision-made wing subassemblies supplied by Ford would never fit—and he said so. When asked how he would manufacture the B-24, Sorensen replied confidently, "I'll have something for you tomorrow morning."

He wasn't kidding. Sorensen sequestered himself in his Coronado Hotel room to prepare for what he later called "the biggest challenge of my life." By 4 a.m. his sums were in order. He estimated that it would take 100,000 workers and a $200 million plant measuring a mile long by a quarter-mile wide to deliver one finished airplane every hour. Sorensen knew that by using the same assembly line methods he had perfected in building more than 30 million Ford automobiles, it was feasible to eclipse Consolidated's modest goal of one airplane per day. That he could calculate detailed production statistics overnight with facts and figures he carried in his head was evidence of Sorensen's brilliance.

Over breakfast the next morning Edsel Ford pledged his full support for Sorensen's bold stroke. George Mead, the government's director of procurement, was delighted by the prospect of receiving 540 bombers a month instead of his goal of 520 a year. Major Reuben Fleet, Consolidated's president, wasn't convinced. His counteroffer: a contract for Ford

to build just 1,000 wing sections. Sorensen flatly replied, "We'll make the complete airplane or nothing."

Back in Dearborn, Michigan, Sorensen explained his scheme to Henry Ford. First he got an anti-war lecture, then a diatribe on how General Motors, the DuPonts, and President Roosevelt were conspiring to drag the country into war and take over Ford's business. But in the end the cranky Henry concurred with the plan and ordered Sorensen to build only complete airplanes—no subassemblies. Ford Motor Company had committed its resources to one of the grandest industrial undertakings in history: construction of the world's largest manufacturing plant to build aircraft using unprecedented methods. Sorensen called the ensuing three years "the most fantastic period of my career."



With little more than a letter of intent from the government specifying a gradual phase-in of operations—first subassemblies, then full component sets to be assembled elsewhere by Consolidated and Douglas, and eventually complete airplanes manufactured on site—an army of Ford laborers set to work in a frenzy. Late in March 1941, 300 men with saws, axes, and bulldozers attacked the 100-acre woodlot where the plant would be situated. A 43-year-old sawmill was brought in from Greenfield Village, Henry Ford's outdoor museum, to convert the felled trees to 400,000 board-feet of lumber. Albert Riggs, an 84-year-old resident of Belleville, Michigan, worked in the plant as a heavy stock handler, and he remembers: "[T]he big circular saw...was steam-powered and six feet in diameter. The logs ran through so fast that the blade got red hot." Even small branches and scrap were saved so they could be used to fuel the mill's boilers.

While the fields were cleared for construction, tool designers and other engineers were dispatched to San Diego to learn everything they could about building B-24s. They were shocked to find that blueprints were virtually nonexistent. Engineering information was six months old due to Consolidated's rapid expansion and constant changes in the airplane's design.

Martin Chapin, now a 76-year-old resident of Port Huron, Michigan, traveled to San Diego with the first wave of 240 Ford personnel. "I was a certified tool and die maker at Ford," he recalls. "When I arrived they put me on salary at $250 per month. Mrs. Chapin and I didn't know what we were going to do with all that money.

"Consolidated had built and assembled aircraft for generations, and they thought our innovations were almost sacrilegious," he continues. "They built airplanes with plumb bobs and levels, while we were used to sophisticated fixtures and gauges."

The cultural differences between Ford and Consolidated were enormous. The Ford team felt they had stepped into another world. They had virtually no aircraft manufacturing expertise and relied on an unskilled work force, so it was imperative that every operation be detailed on a blueprint. Consolidated depended on the ingenuity and experience of its skilled workers, counting on them to alter parts or make changes as needed. Details such as the size, shape, and exact location of rivets were not recorded on blueprints; such decisions were usually left to the discretion of foremen. And Consolidated joined two sections to build a fuselage, installing the wiring and hydraulic lines after the structure was complete. Sorensen likened that methodology to "a bird building its own nest while sitting on it."

"I was quite impressed with Sorensen when I met him in San Diego," says Martin Chapin. "But when he made a presentation in front of a huge drawing of the fuselage and announced, 'These are the cleavage lines [where subassemblies join] we're going to use,' the Consolidated folks thought he was out of his mind. But we proved that our ideas worked, and most of them were adopted by Consolidated."

Ford engineers were particularly amazed by Consolidated's design for a landing gear pivot. It was described as half



a dozen pieces of steel, a couple of large tubes, and some flat plates, all held together by nearly a hundred welds, each of which had to be X-rayed. Ford engineers reduced the parts count to three centrifugal castings—parts made of metal that was spun as it cooled.

Together, Consolidated and Ford agreed on 69 major subassemblies, which Ford divided even further to suit its production philosophy. Instead of two fuselage sections, Ford used 33. Consolidated even moved the infamous outdoor final assembly station inside.

Back in Dearborn, the inevitable conclusion was that Consolidated had never engineered the B-24 for high-volume production. Regardless of how Consolidated had been forming a part, Ford applied its own methods. Consolidated used "soft" tooling that was inexpensive and easily revised. Ford preferred steel dies for punching out aluminum parts and

cast iron dies for forming operations instead of Consolidated's imprecise drop forges and rubber-covered dies. Instead of cutting out parts from metal sheets with saws or routers, Ford punched out parts with blanking dies. Rather than drilling rivet holes in stacked sheets, Ford pierced them during the blanking operation. Hundreds of holes were punched at once in some die-formed reinforcements, while a single stroke of a 500-ton press could punch 2,000 rivet holes in large sheets.

Nine hundred men and women worked seven days a week night and day to design the critical tooling. The first die was ordered four days before the first tree was felled at Willow Run, and more than 30,000 dies—equivalent to eight or nine car model changeovers—were ultimately required to manufacture the bomber's 1,225,000 parts, which were held together by 400,000 rivets.

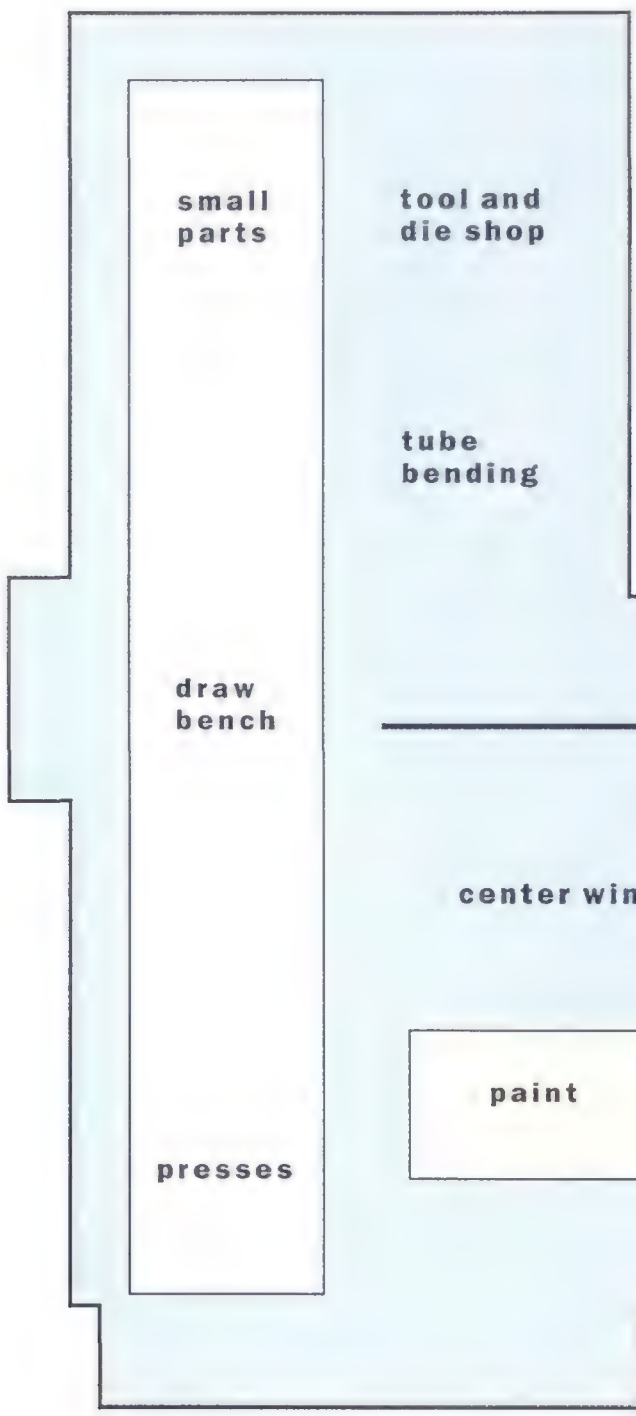


Industrial architect Albert Kahn, designer of Willow Run, called it "the most enormous room in the history of man." Turntables allowed nearly completed B-24s to make a right turn and avoid the taxman in the next county (above).

On April 18, 1941, five weeks after receiving its initial $3.4 million contract for subassemblies, Ford broke ground for the plant. The first concrete footings were poured two days later. On May 1, a New York Central Railroad spur reached the site just as the first piece of steel was erected. The plant was dedicated on June 16, 1941, nine days before the first concrete floor was poured. (Later in the month, the very first contract between the United Auto Workers and the Ford Motor Company was signed.) Tarpaulins protected the heavy machinery from the weather while the plant was being built around it.

In only 107 days a mile-square airport was graded and paved. On October 22, Major Jimmy Doolittle made the first official landing at Willow Run Airport. The last load of concrete for the runways was poured on December 4, three days before Pearl Harbor. With war declared, President Roosevelt announced that America's fate depended on its industrial strength.

While the shell of the building was under construction,





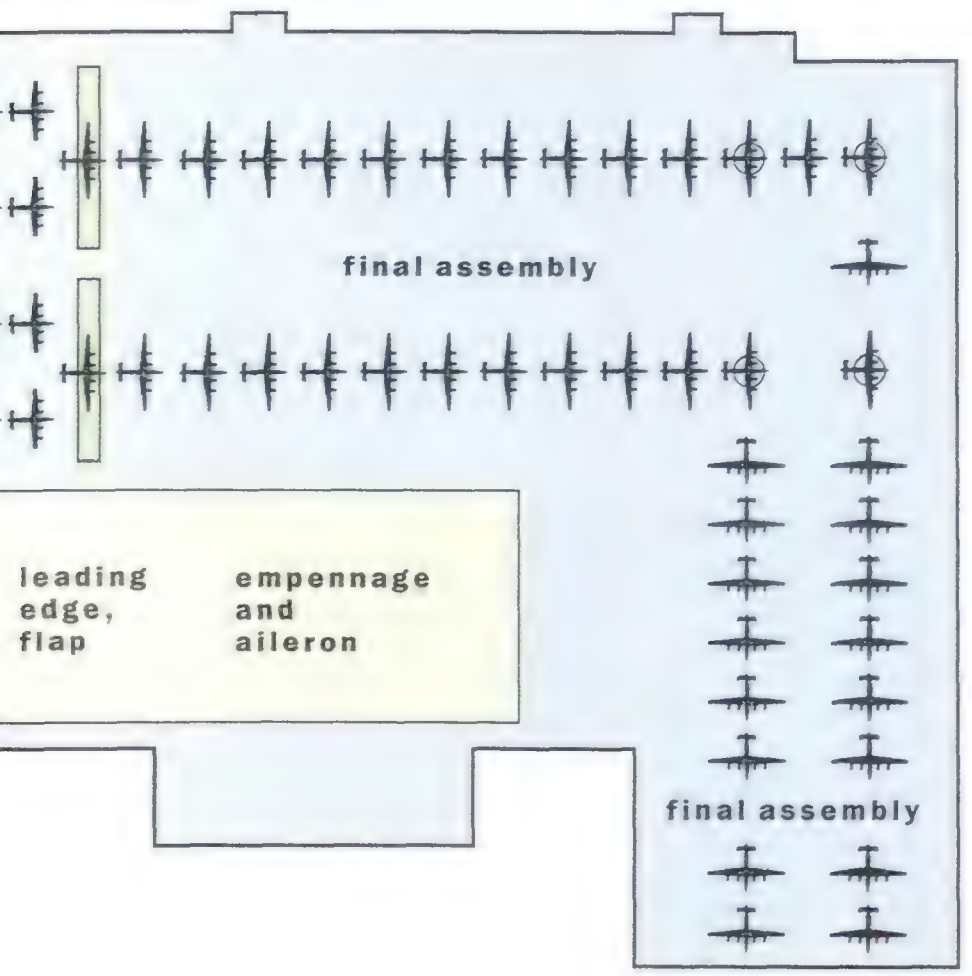
COURTESY CHARLES ORDOWSKI COLLECTION (3)

Sorensen's staff had been working with architects on the plant's floor plan. Ford's scheme depended on an efficient flow of materials from receiving docks to storage cribs to manufacturing and assembly areas. Finished subassemblies, each one precisely interchangeable with the next, were transported to successive assembly stations, by conveyor for small parts, or by overhead crane for more cumbersome pieces.

One of the more remarkable machines in the plant was a 70-foot-long fixture that held the center wing subassembly while mating surfaces and mounting pads were machined. It performed 87 operations in minutes, and the time to build a wing was reduced from 19 days to a matter of hours, a net reduction of more than 10,000 labor-hours per aircraft. Another Ford innovation was the use of seam or spot welding to replace riveting in certain locations. Some 15,000 rivets per airplane were eliminated, reducing weight and saving 35,000 hours of labor every month.



The center wing was the most complex structural component because it supported four engines and the landing gear, so it was given plenty of manufacturing space—two parallel assembly lines—at the west end of the plant. Simpler outer wings and fuselage sections were made in adjacent areas. Finished assemblies met under the high ceiling of a transfer bay, where fuselages and center wings were married. From there the airframes continued down four parallel lines on a west-to-east nose-to-tail migration, rolling on their own wheels as soon as the gear was installed. The four lines merged to two where the outer wing sections were attached. Near the end of the mile-long line, turntables pivoted the airframes 90 degrees to the right for the final roll out the plant's hangar doors and on to the ready line. The only reason for the right turn was to keep the plant from having to cross the county line, a tax-saving expedient.



The harsh spotlights of publicity now turned on Willow Run. The sheer size of the facility was daunting. In his journal, Charles Lindbergh called Willow Run "a Grand Canyon of the mechanized world." With 2.5 million



The plant floor was laid out for efficient flow. Materials became subassemblies, which merged to become major assemblies. Cranes and conveyors moved parts, but as soon as it got its landing gear, a bomber rolled on its own.

COURTESY ORANGE LANTERN



The original crew at the Orange Lantern (left) is no longer around, but much of the atmosphere lingers. Today, Dick Eberts (below) serves his patrons across the same mahogany bar workers rested their elbows on when the tavern opened its doors in 1934.





Sophie Dunayczan-Gorney grew up near Willow Run, worked at the plant, and exchanged letters with a sailor who came home and married her in 1944. All the riveters in her department, which fabricated tail sections, were women.



What Made Willow Run



COLOR PHOTOGRAPHS BY LEE BATTAGLIA

Tony Grey survived 31 B-24 missions over Europe as a tech sergeant, once nursing back a battered bomber and saving the airplane and its crew.



Both Albert Riggs (left) and his wife worked at Willow Run. She was a riveter; he hefted sheets of aluminum into a paint booth. He still lives in the house where he was born.

Wiley Reel (right) worked at Lockheed and taught flying before he began flight-testing Liberators at Willow Run. In 1944 he signed on with General Motors to fly executives, retiring in 1974.





COURTESY CHARLES ORDOWSKI COLLECTION

Ford marked the completion of each run of 1,000 airplanes with a commemorative photograph.

square feet of usable floor space within a 3,200- by 1,280-foot building, the Ford plant had more aircraft manufacturing area than Consolidated, Douglas, and Boeing combined. The press extolled the sheer size of the undertaking without understanding that Willow Run still had to be equipped with effective tools and a functional work force. Production began in November 1941, but 10 months passed before the first B-24 rolled off the line. People began calling the plant "Willit Run?," prompting Senator Harry Truman to undertake a special investigation.

Then the numbers began to mount: from a net output of 56 airplanes for all of 1942 (most of which were assembled by Consolidated and Douglas in Oklahoma and Texas plants) to 31 airplanes in January 1943 and 190 in June. Ford was still a long way from one airplane per hour and the Army's goal of 405 per month, later raised to 535 per month. But by January 1944 the company was building more B-24s than anyone else.

Sorensen had overcome countless hurdles: red tape from Washington, rank skepticism from the aircraft industry, incessant design changes, a quixotic boss, shortages of material and people, and travel restrictions. But by early 1944—shortly after he was pressured into resigning from Ford in a power struggle—his dream had been realized. In March, the Willow Run plant produced 453 airplanes in 468 hours.

The changes surrounding the vortex of activity within Willow Run's walls were cataclysmic. Workers flooded in from all 48 states, Hawaii, Puerto Rico, Canada, and Latin America. Resourceful landlords collected double rent for many rooms: while one tenant worked, the other slept.

To relieve some of the strain, the Public Housing Administration erected an entire town—Willow Village—virtually overnight with dormitories for single workers and small houses for families. The first set of 15 buildings, accommodating 3,000 people, opened early in 1943. A mobile home park followed and was promptly jammed with 1,000 trailer homes. Ramshackle prefab houses rolled in by the truckload. They

Fang Was Here

It has long been rumored that a young Phyllis Diller was a riveter at Willow Run. When queried about her involvement, she wrote to correct the record: "I never worked at the Willow Run Bomber plant. It was my husband Sherwood Diller who worked as an inspector of all systems, electrical, hydraulic, etc. He started out there working on the cowling. We lived in Ypsilanti from 1940–42 and then transferred to the Alameda Naval Air Station in California."

Have You Driven a B-24 Lately?

Wiley Reel, a 77-year-old retiree living in Belleville, Michigan, had an interesting assignment at Willow Run: copiloting on test flights before each airplane was turned over to the Army. The tall, sincere Reel, who could be a stand-in for Jason Robards, remembers what it was like: "We had three shifts of pilots and engineers with 25 or 30 crews per shift to keep up with production. Most of the personnel came from the airlines or from corporate aviation. All of us worked two days in a row and then had two days off, seven days a week.

"Our department worked around the clock except for the fact that initial flights were made only during daylight and in good weather. If there were no squawks, an airplane could be accepted on the first flight. If there was a problem, we had it fixed and took the airplane back up to check out the repair.

"Our preflight inspection took one and a half to two hours. In the air, we checked out all instruments and the long-range radios, feathered the props, and recorded the time required to extend and retract both the flaps and the landing gear. The full checklist took about an hour. On some of the airplanes we test-fired the machine guns over Lake Huron with live ammo and dropped dummy bombs.

"We typically cruised at 180 mph and up to 10,000 feet altitude. The captain and I would trade takeoffs and landings. The controls of the B-24 were quite heavy and you could almost lift yourself out of the seat during the landing flare. One of the copilot's most important jobs was to monitor manifold pressure during takeoff. If one of the turbocharger's wastegates stuck, it could blow the cylinders right off an engine.

"We affectionately called the plant workers 'plow mechanics' because very few had ever been close to an airplane. Nevertheless, they built a very fine product. We were able to buy 75 percent of them on the first flight, which I think is incredible.

"Charles Lindbergh worked for the Ford Motor Company as a consultant and lived near Belleville during the war. Once he was talking with some engineers about adjusting prop pitch at high altitude. The concern was whether or not the lubricating oil would congeal and lock the setting. One of our copilots was listening to the conversation without saying anything when Lindbergh turned and asked his opinion. I thought that was very democratic of him.

"Luckily, I never had a forced landing in a B-24. The most serious problem I ever faced was a disconnected fuel return line, which I discovered on one engine during the ground inspection.

"In about 18 months at Willow Run I logged 447 hours in B-24s during 307 flights. Believe me, I enjoyed the opportunity to contribute to the war effort while also advancing my flying skills."

While Reel was making his contributions at Willow Run, Tony Grey, now a 70-year-old auto industry consultant in Dearborn, Michigan, spent his time in B-24s as a flight engineer during 31 bombing missions in the European theater. Before a mission, he reminisces, "we could sleep a half-hour [later] than the B-17 crews because we cruised at 175 mph to the target versus their 160 mph. The B-24 carried more bomb load and burned less fuel but had a lower ceiling. We had superior engines and a more advanced wing design, but the B-17s could supposedly absorb more structural damage and continue flying.

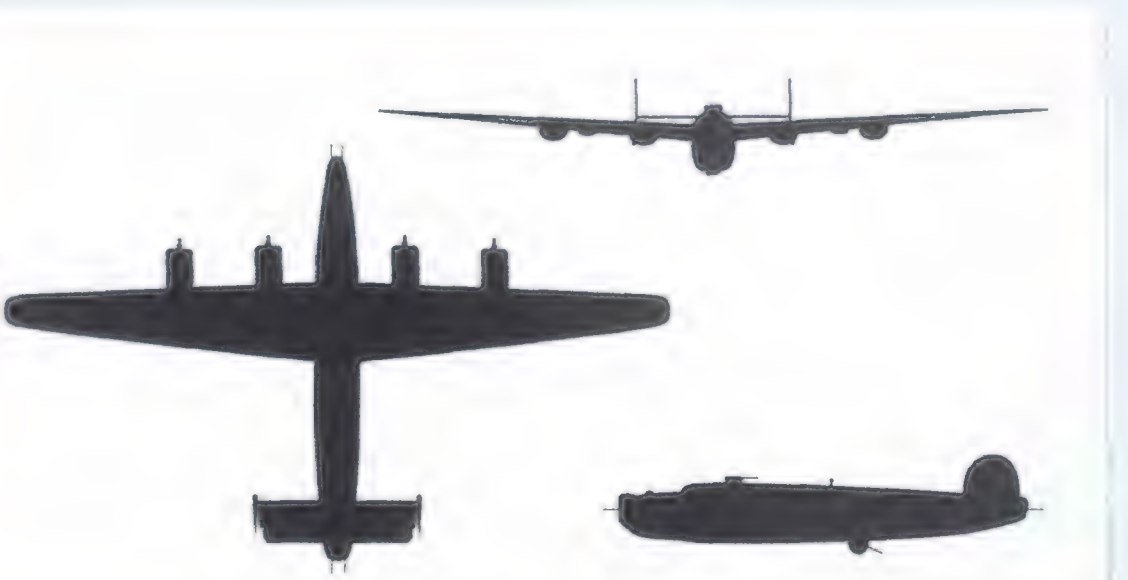
"My crew trained in scruffy D-model B-24s, but we were issued a new Ford-made J-model for the trip over from Mitchel Field on Long Island to a receiving base in Land's End, England. The Ford-built airplane was quieter, tighter, warmer, and handled much better than what we had in training. Everything was spotless and flawless. It even smelled better, not just because it was new but because it was well made. The Ford airplanes were consistently good in my experience.

"Unfortunately, they took that ship from us when we arrived and my crew had to suffer with older airplanes until we proved ourselves during the first 10 missions. The newer, better airplanes went to the more seasoned crews because they were more likely to bring them home."

Grey's major moment with the 93rd Bombardment Group came on a mission to bomb an airfield near Braunschweig, Germany. In his words: "On the first pass, clouds obscured the target. We tried to use our PFF [an early form of radar] on the second pass but that was also unsuccessful. We dropped our load on the third pass but took a hit—an 88mm shell which passed through the center wing without exploding. Immediately we lost number-one and number-two engines, our life rafts, and three out of four radio systems. Fuel began leaking profusely and we were sinking 300 feet per minute with the remaining two engines set very rich to forestall overheating since they were running well beyond normal output.

"We set a course for Sweden, where we intended to crash-land if necessary. But luckily I was able to reconfigure fuel delivery to stem the loss of gasoline and restart one engine. We set the three engines to limit our rate of descent to 100 feet per minute, so we crossed the channel—and the flak barges—with 4,800 feet on the altimeter."

For actions that saved the ship and crew, Grey was awarded an Oak Leaf Cluster for his Distinguished Flying Cross.





COURTESY CHARLES ORDOWSKI COLLECTION (2)

Henry Ford, here with General "Hap" Arnold, favored a strong U.S. defense but not involvement in a European war.

were loaded with the floor sections on top and roofs on the bottom, and as a crane lifted the pieces off, workers nailed them up in speedy succession. Each house had a crude coal stove, and residents had to get by with iceboxes instead of refrigerators. They were the lucky ones; those not so fortunate lived in converted gas stations, shacks, or tents. By the end of 1943, when 42,331 employees worked at the plant, Willow Village was providing temporary shelter for 15,000, a population greater than Ypsilanti's.

Florida Goodson was 18 years old when she and her family drove from Austenville, Virginia, to Michigan in order to find war work. "We arrived on a cold and snowy day in January of 1944," she recalled from her present home in Cheney, Washington. "My mother, my father, and I were all hired the first day, and they referred us to Willow Village to find a place to stay. We moved right into a new two-bedroom unit that rented for about $25 per month. Two maintenance men uncrated the furniture and built a fire in the stove, leaving us enough coal and ice for the icebox to last until supplies could be delivered.

"Our new home was comfortable and clean, but the walls were paper thin. If the neighbors cooked onions, we could smell them.... The apartments were built in a row with shared walls, and they all looked alike. Once when we got off the bus at the wrong stop, we had trouble finding our unit."

Fifteen thousand women worked at Willow Run. Sophie Dunayczan-Gorney, who resides today in Belleville, Michigan, reported for work in 1942 at age 19. "I got lost the first day I took a bus to the factory," she remembers. "After I was trained for two weeks as a riveter, I worked on the aluminum framework for the tail fins. The noise level was so high we couldn't talk to each other. Hair nets were required but ear protection wasn't. One day I accidentally drilled a hole in my thumb and had to walk quite a ways to the nurse's station.

"My section ran on three shifts but I never had to work nights. It was tiring work because we moved quickly and never sat down. We had a 15-minute break in the morning and afternoon and 30 minutes for lunch. The only men in my section were inspectors. My brother worked on wings, and it was even noisier there. All things considered, I enjoyed my work, particularly the opportunity to meet so many people from all over the country."

In those days business was brisk at the Orange Lantern bar, in no small part because it was located just off the walkway between the plant and Willow Village. Dick Eberts, who operates the Orange Lantern today, spent the war in Europe, and his decorations, including a Bronze Star for capturing German soldiers near the Ruhr River, hang discreetly behind the bar. "While I was gone, my parents opened the bar at seven in the morning and closed at eight p.m. because the liquor ration was but 12 cases a week," he says. "It was usually so crowded that somebody had to leave to make room for the next patron."

When the books were closed on the war effort, Ford's Willow Run bomber plant had logged an enviable record. During 1944, its peak year, the plant had produced 93 million pounds of airframes (a more revealing measure of productivity than units since airplane sizes differ) with fewer than 29,000 workers, not counting thousands more outside the plant, a feat that no other manufacturing facility even approached. Willow Run's output nearly equaled Japan's entire production that year and was approximately half that of each of the nations of Germany, Great Britain, and the Soviet Union. Ford's assembly line methods led to a remarkable drop in the delivered price for B-24s: from $238,000 each in 1942 to $137,000 in 1944. A total of 8,685 B-24s were built at Willow Run, including 1,894 knocked-down kits shipped to other plants for assembly. In the spring of 1945, the plant received an Army-Navy "E" citation for exceptional war work.

When the hostilities ended, the Ford Motor Company did not exercise its option to buy Willow Run from the government, and the plant was sold to Kaiser-Fraser for production of automobiles (and later C-119 cargo planes). General Motors acquired the facility in 1953 after fire ravaged the company's Hydra-Matic transmission plant in Livonia, Michigan. After a frantic 12-week conversion, GM began making automatic transmissions at Willow Run and continues manufacturing them there to this day. Some of the overhead-crane and hangar-door equipment originally installed 50 years ago by Ford is still in regular use.

And life goes on at the Orange Lantern saloon. Proprietor Eberts' face has a few wrinkles, and the price for a glass of draft beer has shot up from 10 cents in the 1940s to $1.25 today. Nephew James "Bud" Fandrich helps tend bar. Though he's too young for World War II stories, Bud does have a favorite anecdote. "As a young boy I used to sit by the road and watch for Mr. Ford's car to go by on the way to Willow Run," he says. "It was a thrill for me just to wave at such an important man. But you know, he never waved back." ✈

Ford's assembly line methods produced 8,685 Liberators; by 1944, the price of each had dropped by 40 percent.



The Wild Blue Yonder Goes to the Beach

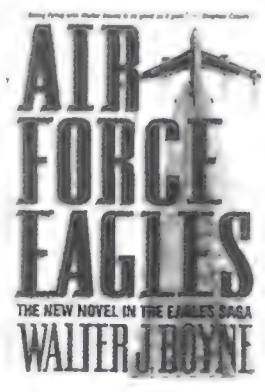


DESIF COOPER

Air Force Eagles *by Walter J. Boyne. Crown Publishers, 1992. 464 pp., $20 (hardbound).*

Air Force Eagles is the final book in a trilogy by Walter J. Boyne that spans much of the history of the airplane. Boyne, a former director of the National Air and Space Museum and the founder of *Air and Space/Smithsonian*, seems undaunted by obstacles that might give another writer pause. Few would attempt a series of novels wrapped around so much of the story of aviation, and most white writers shy away from portraying the minority experiences that figure largely in his latest book.

Boyne's protagonist is Frank Bandfield, a pilot with an intuitive sense of engineering and a persistent good streak. The first book, *Trophy for Eagles*, introduced Bandfield at Roosevelt Field in 1927 and followed him through the late-1920s air racing craze on both coasts and the buildup of air power in Europe as the Continent girded for war. *Eagles at War*, the second book, began in 1938 with the United States working to catch up to Europe in airplane production. The centerpiece of the tale was the twin-jet Messerschmitt Me 262 fighter, which a German named Bruno Hafner, a former ace with the business ethics of Ivan Boesky and the appetites of King Farouk, was dedicated to developing. Boyne wove a complex tale of greed, deceit, politics, and dirty tricks within the U.S. aircraft manufacturing establishment, with all the worst traits embodied in the person of Troy McNaughton, an unprincipled captain of industry who specialized in building defective aircraft and bilking the government.



In *Air Force Eagles*, the Nazi menace has been replaced by the Ku Klux Klan. Bandfield's new nemesis is Milo Ruddick, an old-style Southern politician and thinly veiled Klansman with a vendetta against our hero. The plot culminates in the 1957 crisis at Little Rock, Arkansas, which tested the nation's new integration policies. John Marshall, a black airman victimized by prejudice during World War II and the Korean War, embodies the burden faced by minorities during this troubled period of transition. As his rationale for ending the trilogy in Little Rock, Boyne points out in an author's note that the U.S. armed forces led the effort toward redressing racial injustice after

President Harry Truman ordered them to integrate.

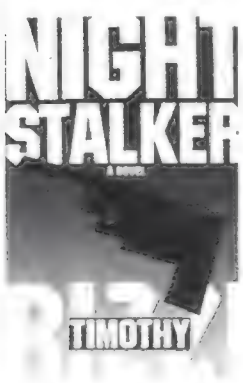
If it all occasionally sounds melodramatic, that's because it occasionally is. Boyne delivers relentless action, but it's often at the expense of his characters, who become distortions. A more striking flaw in all three books is the intermittent introduction of such real figures as Charles Lindbergh, Amelia Earhart, and Adolf Galland. Their appearances are inevitably jarring—akin to watching policemen break into song in the short-lived TV series "Cop Rock"—and a distraction from the storytelling, which depends a great deal on momentum. Such icons might have worked had they appeared as distant presences.

Although Boyne's final tale might seem strained and hurried compared with his earlier books, buffs who enjoy recognizing real milestones of aviation history behind scanty fictional camouflage should enjoy the entire trilogy. Taken as a whole, the world Boyne creates provides consistent entertainment.

—George C. Larson

Nightstalker *by Timothy Rizzi. Donald I. Fine, Inc., 1992. 430 pp., $21.95 (hardbound).*

Never mind that the B-2 stealth bomber isn't operational; in *Nightstalker* it performs beautifully, penetrating deep into hostile airspace on a super-secret mission. In this book, the enemy is familiar but now nonexistent: the Soviet Union. The characters too seem familiar: there is Duke James, an all-American pilot; Grigori Koiser, an idealistic Soviet defector; and a KGB mole known only as "André." There's also a supercomputer/air defense radar installation buried 164 feet underground. We've seen it all before, but what makes this book such a good read are the endless flight scenes, in which Rizzi puts the reader inside an assortment of state-of-the-art cockpits. We see the pilots' displays glowing yellow and red with the threat of a missile strike. We feel the force that slams their bodies back into their seats during high-G maneuvers. We hear the high-pitched whine of radar that has just locked on to a target. Chock full of detail at over 400 pages, the book also contains a glossary and maps of the flight routes.



—Diane Tedeschi



At Sea, *directed by Greg MacGillivray, produced by Greg MacGillivray and Alec Lorimore. A MacGillivray Freeman Film.*

Visitors to Washington, D.C., should be sure not to miss the new U.S. Navy Memorial, across from the National Archives Building on Pennsylvania Avenue. In addition to a variety of interactive videos and other displays, the visitors' center features a 35-minute, 70mm film set on the Navy carrier USS *Constellation.* Produced by the creators of the IMAX film *To Fly,* which has been so popular at the National Air and Space Museum, *At Sea* follows a catapult officer aboard the carrier and offers breathtaking footage of F/A-18 Hornets, F-14 Tomcats, and other aircraft. The giant-screen movie is shown every 45 minutes. Be forewarned: after you see this movie, you may decide to enlist.

The Nemesis Mission *by Dean Ing. Tom Doherty Associates, 1992. 384 pp., $20 (hardbound).*

If you judge a book by how fast it makes you read through the action scenes, Dean Ing's *The Nemesis Mission* is a very good book. Don't expect surprises. His characters are clichés: a grizzly but good-hearted old aircraft designer, a wise national security manager, a feisty, overachieving female pilot (with tragedy in her past that has made her tough), and cruel and greedy drug lords from Colombia and Peru. But the spy plane around which the story is constructed is so imaginative that by the time you get to the narrow escapes, you're rooting for the airplane as much as for the crew.

The Nemesis is a lightweight polymer craft that uses a turbocharged rotary engine to climb and solar cells to hover over its target at 75,000 feet. Its mission is to spy on a cocaine operation that has invaded Mexico from Colombia and, with operatives from the CIA, DEA, and FBI, to thwart a hostage-taking scheme concocted by the drug kingpins. Ing manages a few clever twists but basically the plot is predictable: there's never any doubt that the good guys will win, the love interest will develop, and the lone-wolf businessman will prove superior to the Company. It's all very implausible and very fun to read.

—Linda Shiner

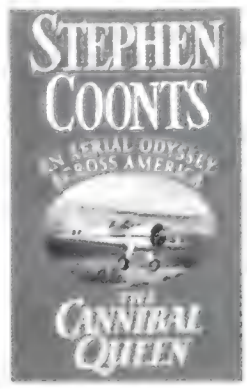
Scorpion Strike *by John J. Nance. Crown Publishers, Inc., 1992. 384 pp., $21 (hardbound).*

This novel must have been written at a pace Stephen King would admire: though it's based on the Gulf war, it was at the printer barely a year after the last shot rang out. In a nutshell: two Air Force pilots take off in a C-141 transport in hot pursuit of a stash of artificial virus cooked up by Iranian scientists for use in biological warfare. (Cargo plane drivers everywhere will no doubt relish this uniquely glamorous portrayal of their profession.) The writer, a former airline pilot who himself flew C-141s as an Air Force Reserve pilot during the Gulf war, is happy to hew to the conventions of techno-thriller writing: the characters have names like Walt Perkins and Doug Harris, their insights run to thoughts like "The desert could be beautiful in its stark simplicity," and their conversation is peppered with exclamation points (though no alarming vulgarities; an occasional "Jesus!" and "Goddammit, Will!" is as heated as it gets). *Scorpion Strike* would make fine beach reading: in both the flying episodes and the ground action, the author is generous with vivid details, and the writing is clean and taut throughout. Nowadays, that's more than you can expect from Stephen King.

—Perry Turner

The Cannibal Queen: An Aerial Odyssey Across America *by Stephen Coonts. Pocket Books, 1992. 352 pp., $22 (hardbound).*

Fiction seems to come easily to Stephen Coonts, creator of lantern-jawed aviator Jake Grafton and author of *Flight of the Intruder* and *Final Flight.* Nonfiction, however, is another matter.



In 1991, Coonts' publisher underwrote his two-month exploration of the United States—all 50 of them—in a 1941 Stearman. The result is an excruciatingly detailed account of a pilot's summer vacation. We learn what



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airports he stopped at, the gender of each person who answered his radio calls, the wind component at each final approach, how good or bad each landing was, how much fuel the Stearman took, what the weather guys said, what the author had for breakfast, lunch, and dinner, and the state of each night's sleep. When things get slow, we learn Coonts' opinions on the state of general aviation (defunct), Boulder, Colorado (too many aging hippies), and politicians (walking pork barrels). As a great fan of Coonts' books I had eagerly anticipated the publication of his first non-fiction saga, but I was disappointed to find that while you can sink your teeth into his novels, *The Cannibal Queen* has the consistency of a Twinkie.

—Patricia Trenner

The Trikon Deception *by Ben Bova and Bill Pogue. Tor Books, 1992. 309 pp., $19.95 (hardbound).*

It's 1998, and pollution is threatening life on Earth. Fortunately, hope orbits overhead in the form of Trikon Station, a multi-national research laboratory devoted to creating genetically engineered pollution-eating microbes—that is, unless jealousy, theft, insanity, and murder first lay the noble cause to waste.

Veteran science fiction writer Ben Bova and Bill Pogue, former commander of Skylab, convincingly set the scene aboard their orbiting lab, and the detailed descriptions of everyday life in microgravity are fascinating. The space station's inhabitants aren't as realistically rendered, however, and their boilerplate characterizations and stilted dialogue ("You dodge projectile vomit very well," a male scientist tells the station's attractive female doctor) reduce them to mere types. *The Trikon Deception* could have been a gripping story; instead, it's simply a good though somewhat predictable read.

—Karen Jensen

Aces *by Robert Denny. Donald I. Fine, Inc., 1990. 294 pp., $18.95 (hardbound), $4.99 (paperback).*

Robert Denny must know whereof he speaks in this novel about B-17s and Me 262s over Germany: he flew 35 bomber missions himself and won the Distinguished Flying Cross. But that alone doesn't make for a good book. While its aerial combat scenes are often exciting, *Aces* slams back to earth hard when people are required to do people things. This is a book in which, after making love, a woman says, "Oh Golly. That was incredible. I didn't know it could be like that." The story of Mitch Robinson, his close friend Lon Amundson (male bonding at its stickiest), and the women they love, *Aces* struggles mightily with weighty issues, like the irony of cousin battling cousin in the skies over Europe. "Why, there may be a young von Moltke over there right now who looks just like you," says a relative to Mitch in one of the book's heavy-handed foreshadowings. "Wouldn't it be fascinating to find out?" In a word, no.



Aces: Iron Eagle III, *starring Louis Gossett Jr. Directed by John Glen, produced by Ron Samuels. A New Line Cinema release. MPAA rating: R.*

Hollywood's latest airborne offering is this summer's *Aces: Iron Eagle III.* In this third, and increasingly implausible, installment of the "Iron Eagle" series, four over-the-hill aces from the United States, Germany, Britain, and Japan pit their World War II-vintage crates against missile-toting modern jet fighters. Louis Gossett Jr. reprises his role as Chappy Sinclair, an Air Force colonel who doesn't always go by the book. When a friend is shot down by drug cartel bad guys, Chappy recruits his fellow airshow pilots to fly to Peru and blow up a cocaine factory. Things get complicated when the dead pilot's sister, played by bodybuilder Rachel McLish, and a streetwise ghetto kid come along for the ride. The opening airshow sequence has Spitfires and Lightnings tangling with Messerschmitts and Zeros, but that initial momentum is soon lost as Chappy and friends walk through stilted dialogue toward the film's inevitable slam-bang climax. The final 20 minutes of *Aces* is one long explosion interspersed with dubious feats of aeronautical prowess.

—D.C. Agle

Calendar

August 8 & 9
Beaver County Airshow. Beaver County Airport, Chippewa, PA, (412) 846-9922.

August 13–16
Sentimental Journey to Cub Haven Fly-In. Piper Memorial Airport, Lock Haven, PA, (717) 893-4207.

August 14–16
"Rock Around the Prop." An exhibit of restored airliners from the 1940s and '50s. Mid-Atlantic Air Museum, Reading Regional Airport, Reading, PA, (215) 696-7736.

August 15 & 16
Wings of Eagles Airshow. Thunderbirds. National Warplane Museum, Geneseo Airport, Geneseo, NY (716) 243-0690.

August 16
Ice Cream Social. Sponsored by the Experimental Aircraft Association's Antique/Classic Chapter 11. Homebuilts and radio-controlled models. Capitol Airport, Brookfield, WI, (414) 962-2428.

August 22 & 23
Air Show '92. Sponsored by the Prairie Aviation Museum. Bloomington, IL, (309) 663-7632.

September 12
Airline Collectibles Show & Sale. Sponsored by the Tri-State Airline Historical Society. Buy, sell, and trade airline memorabilia. Holiday Inn, Elizabeth, NJ, (212) 689-3936.

September 12 & 13
Mid-Eastern Regional Fly-In. Marion Municipal Airport, OH, (513) 849-9455.

September 22–24
National Business Aircraft Association's 45th Annual Convention. Dallas Convention Center, Dallas, TX, (202) 783-9000.

September 26 & 27
Fall Festival of Flight. Sponsored by the East Coast Experimental Aircraft Association. New Castle County Airport, Wilmington, DE, (301) 942-3309.

International Airshow '92. Alliance Airport, Ft. Worth, TX, (817) 624-2727.

Santa Fe Air Show: "Peace Through Aviation." Sante Fe Airport, NM, (505) 982-9863.



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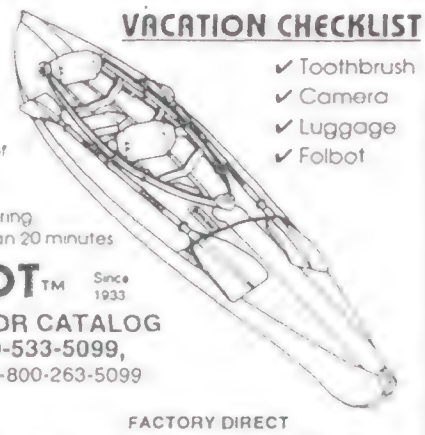
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Credits & Further Reading

Catching Rays. Laurence A. Marschall, a columnist for *The Sciences*, is a professor of physics at Gettysburg College.

Amelia Earhart: Is the Search Over? Stephan Wilkinson, an *Air & Space/Smithsonian* contributing editor, is a member of TIGHAR. In 1986 he participated in the group's ninth search for *L'Oiseau Blanc*.

Further reading: *Amelia Earhart*, D.L. Rich, Smithsonian Institution Press, 1989.

The Sound of Wings, Mary S. Lovell, St. Martin's Press, 1989.

Aliens in the Basement. Frequent *Air & Space/Smithsonian* contributor Frank Kuznik hopes to join the upcoming archeological dig at the Roswell crash site.

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The El Centro Blues. George C. Larson is the editor of *Air & Space/Smithsonian*.

Further information: *Threshold: The Blue Angels Experience, Winter Training*, VHS, written by Frank Herbert, produced and directed by Paul Marlow, Threshold Releasing, 1973.

Long Distance Calling. J. Kelly Beatty is the senior editor at *Sky & Telescope*. He has been covering NASA and international space programs for 20 years.

Further reading: "Communicating with Voyager," Larry N. Dumas with Robert M. Hornstein, *Aerospace America*, May 1990.

The Name Game. Elaine de Man is a frequent contributor to *Air & Space/Smithsonian*.

"This is Bobby Yon, Altha Air Service." David Savold is an associate editor at *Air & Space/Smithsonian*.

Looking at Earth. Priscilla Strain and Frederick Engle work at the National Air and Space Museum's Center for Earth and Planetary Studies, Strain as program manager and Engle as geographer.

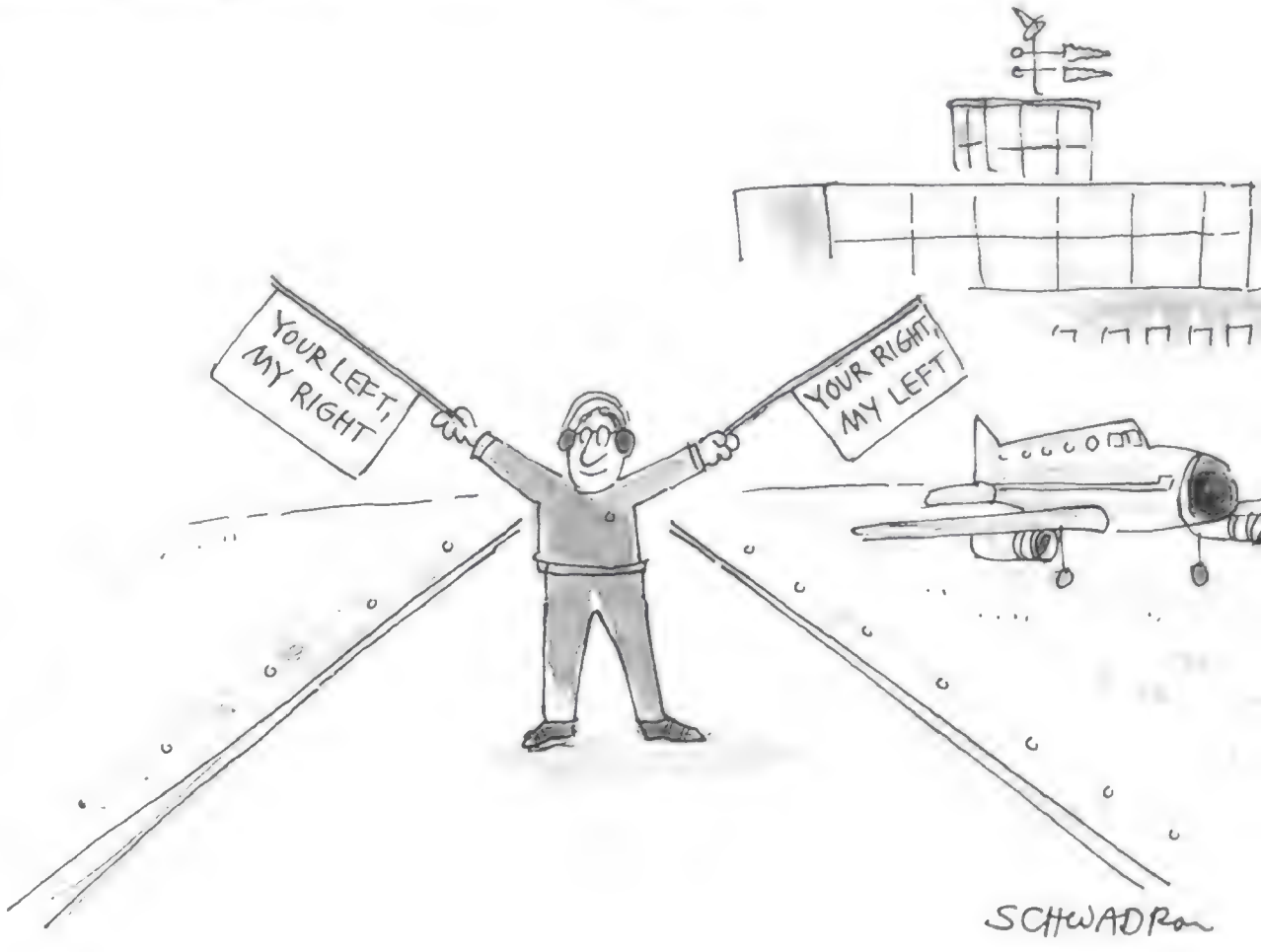
Willow Run. Don Sherman lives a few miles from Willow Run. When not restoring his 1960 Cadillac convertible, he writes about cars and the auto industry. He is also an editor-at-large for *Motor Trend*.

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My Forty Years With Ford, Charles E. Sorensen, W.W. Norton, 1956.

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Station 357. Tom Huntington is the managing editor of *Air & Space/Smithsonian*.



"The Satellite Sky" Update/31

These regular updates to "The Satellite Sky" chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

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4-29-92 TT

Cosmos 2186
5-28-92 PL

Progress M-12
4-19-92 TT

Rohini
5-20-92 ISRO

300 to 630 MILES

Cosmos 2184
4-15-92 PL

EUVE
6-7-92 CAC

630 to 1,250 MILES

Cosmos 2187-94
6-3-92 PL

21,750 to 22,370 MILES

Inmarsat 2-F4
4-15-92 KOU

Palapa B4
5-14-92 CAC

Telecom 2B
4-15-92 KOU

Deletions

90 to 300 MILES

Cosmos 2027
down 4-14-92

Cosmos 2107
down 4-5-92

Cosmos 2182
down 5-30-92

Inoperative but still in orbit

300 to 630 MILES

Cosmos 2074 Nadezhda Orbcomm-X

21,750 to 22,370 MILES

Raduga 20

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90 to 300 MILES

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In the Wings...

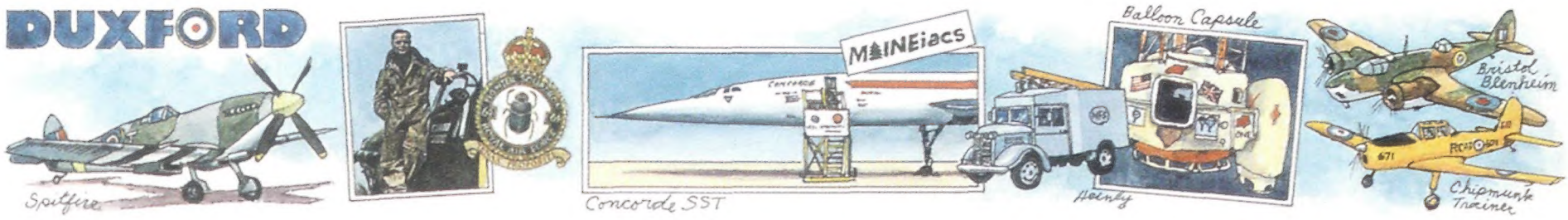
On the First Plane to Petropavlosk. When Kamchatka was part of the Soviet Union, not even Soviet citizens could visit its capital city. Now Petropavlosk is about to become a tourist attraction, and the first airline to wriggle through U.S. and Russian red tape wins the trade route.

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Flying the Canyon. Tourist flights may provide the best view of the Grand Canyon, but how much do they disturb its environment? And is the view worth the risks?

Selling SETI. In October NASA will turn on the radio beacons in its Search for Extraterrestrial Intelligence. The struggle to get started has taught SETI advocates that before you can communicate with an alien civilization, you must first learn to communicate with your own.

Mighty Eighth Reunion. They were young men and women 50 years ago when they fought together against a common enemy. This summer the Eighth Air Force returned to England and found that some things just don't change.



JOHN HEINLY

Station 357

Standing by the runway at England's Duxford Airfield as a cool autumn breeze blows from the low green hills in the distance, even the most unimaginative visitor may strain to hear the sound of Hurricanes and Spitfires returning from battle. It was from Duxford, a Royal Air Force Base in 1940, that Douglas Bader's "Big Wing" flew off to fight the Luftwaffe during the Battle of Britain. On September 15, a date now celebrated as Battle of Britain Day, the Big Wing flew three sorties, helping to break the back of the German air offensive.

There are still Hurricanes and Spitfires at Duxford, but their tasks today are those of educating and entertaining. The airfield is now a branch of Britain's Imperial War Museum and the centerpiece of the IWM aviation collection. Because of its rich aeronautical history, "the site itself is a museum," says Duxford director Ted Inman. Located just south of Cambridge on the M11 highway, it hosts some 400,000 visitors a year, who come to see everything from a Concorde SST to a World War I Spad VII.

The Imperial War Museum is funded mostly by the government. Its aircraft collection consists of "about 110 altogether, if you count major components," says Inman. Several private collections are also housed at Duxford, including the Stephen Grey fighter collection, which is flown at shows at the still-operational airfield. "We don't fly our own, generally," says Inman. "It's the best of both worlds. Other people are flying things that we couldn't afford to fly."

Duxford is currently in the middle of a substantial expansion effort. A Land Warfare Exhibition Hall was just opened, and the next big push, now in the fundraising stage, is for the American Air Museum in Britain, a showcase for U.S. aircraft. Most of the airplanes slated for the new museum are already at Duxford, including a TBM Avenger in the colors of the one President Bush flew in the Pacific. Some of the larger ones are kept outside. "We must get the airplanes under cover," says Inman, who points out that a B-52 donated by the U.S. Eighth Air Force in 1983 is already showing signs of deterioration from the elements.

The best place to start a tour of the current facilities is Hangar 1—the mammoth "superhangar" dedicated in 1986 by helicopter pilot Prince Andrew. Like most of the buildings at Duxford, it's a working hangar with restoration and repair work under way, permeated by the not unpleasant odors of paint and oils and stuff that gets underneath fingernails.

Duxford Airfield, Duxford, Cambridge CB2 4QR, United Kingdom. Phone Cambridge (0223) 835000. Open daily 10 a.m. to 6 p.m. (summer) and 10 a.m. to 4 p.m. (winter), except December 24–26 and January 1. Admission about $7.75; discounts for seniors, children, and students.

Hangar 1 houses some seriously large airplanes, including a British Vulcan bomber and an American B-29. There's also a Sunderland flying boat that once served as a landlocked nightclub in France. There are smaller items too, like tanks and trucks, as well as the capsule Richard Branson and Per Lindstrand used in their1987 hot-air balloon crossing of the Atlantic.

Outside the superhangar is Duxford's collection of civil aircraft, which actually belongs to a private group called the Duxford Aviation Society. Undoubtedly the greatest attraction is the supersonic transport. "Two million people have walked though this Concorde," says Duxford press officer Frank Crosby. This particular aircraft is one of two pre-production versions used for a variety of flight tests. The word "Maineiacs" emblazoned on the fuselage commemorates the civil transatlantic speed record the SST set from England to Bangor, Maine, in 1974.

Hangars 3 through 5 were three of the airfield's first buildings, erected in 1917 to provide an airbase during World War I. (The fourth of these original hangars was destroyed on film for the 1969 movie *The Battle of Britain.*) The wooden lattice ceiling supports and skylights of these older hangars give them an appropriately airy, old-fashioned feel.

Hangar 3 shelters a small exhibit devoted to the Eighth Air Force. From the end of 1942 until December 1, 1945, Duxford was taken over by the Yanks and became the Eighth's "Station 357." The Americans nicknamed the airfield "Duckpond" because of its poor drainage, but otherwise were satisfied with their temporary home. As one pilot recorded in his diary: "We are situated six miles from Cambridge and fifty miles north of London. The set up is practically a Shangri-La! The barracks are steam heated and of double brick. The hangar theater has an organ." The three P-47 squadrons of the 78th Fighter Group were stationed here, their aircraft noses decorated in a black-and-white check pattern. Eleven of those Duxford Thunderbolts were lost in a single day during the Normandy invasion, and by the end of the war 128 pilots from Station 357 had been killed in action.

Another reminder of the war years is Duxford's operations room, which was restored from photographs to look as it did when Douglas Bader commanded the Duxford Wing against the Luftwaffe. The men and women who worked here kept track of aircraft—friendly and enemy—on a table-size map and directed the defending squadrons into battle. When Duxford became a museum in the 1970s, the room had been long dismantled, and its restoration in large part drew upon the memories of people who had worked there. Frank Crosby says, "It's an ongoing thing, really. People come in and say, 'That board shouldn't be there, it should be over there,' so we change it." Only a single detail jars: in the briefing area behind the operations room, a model Bf 109 is poised in the killing position behind a Spitfire. At Duxford, it seems the placement should be reversed.

—Tom Huntington

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